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ABSTRACT

The purpose of this guide is to help school administrators and instructors in planning and developing new programs in the air pollution control field, or in evaluating those in existence. It contains course outlines for technical specialization courses as well as necessary basic science and communication courses. Also included are plans for laboratories and the equipment needed, with approximate costs. Related areas such as advisory committees, faculty requirements, student selection, scientific and technical societies, and others are presented. This guide represents one approach to training technicians to work in a highly complex area. It can be modified to meet a particular institution's local, State, and regional needs. The bibliography presented with the curriculum includes a suggested library content which is classified as basic encyclopedia and reference index material, reference books, periodicals and journals, and visual aids. (Author/EB)

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A SUGGESTED TWO-YEAR POST HIGH SCHOOL CURRICULUM

AIR POLLUTION TECHNOLOGY

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A SUGGESTED TWO-YEAR POST HIGH SCHOOL CURRICULUM

AIR POLLUTION TECHNOLOGY

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FORWORD

It has been pointed out that man could live several weeks without food and several days without water, but that he would perish in a matter of minutes without air. The protection of this thin layer of life-supporting atmosphere should therefore be the concern of every citizen.

The federal and state governments have enacted legislation in recent years designed to improve the quality of the air we breathe, and have appropriated funds for research, training and control purposes.

The manpower required to improve air quality encompasses many different disciplines and training levels. In the scientific and technical aspects of air pollution research and control, engineers, chemists, physicists, biologists, meteorologists and others are needed. Support personnel required for these scientists include trained technicians who, with a minimum of supervision, can perform detailed field sampling as well as precise laboratory analytical tests for various air pollutants. This valuable service will free engineers and scientists to perform research and related control activities.

The program presented in this guide is designed to prepare highly qualified technicians to work in the air pollution control field after a two-year program of full-time study. It has been reviewed by experts in the fields of air pollution control and training. The purpose of the guide is to help school administrators and instructors in planning and developing new programs, or for evaluating those in existence. It contains course outlines for technical specialization courses as well as necessary basic science and communications courses. Also included are plans for laboratories and the equipment needed, with approximate costs. Related areas such as advisory committees, faculty requirements, student selection, scientific and technical societies and others are presented. The Guide was prepared at Sante Fe Community College in Gainesville, Florida under the terms of a contract with the U. S. Office of Education. The Project Director was John M. Turner.

It should be kept in mind that the guide represents one approach to training technicians to work in a highly complex area. The guide can be modified to meet a particular institution's local, state and regional needs.

Alan J. Robertson
President
Santa Fe Community College

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THE AIR POLLUTION TECHNOLOGY PROGRAM

Air pollution is a problem belonging almost exclusively to urbanized, industrialized nations. Generally, as industry, technology and urbanization have increased, the amount of air pollution has increased proportionately.

It was estimated by the U. S. Department of Health, Education and Welfare that for the year 1967, there were 142 million tons of pollutants emitted into the air of the United States. These pollutants were classified into 5 specific types, and came from 5 major sources. Motor vehicles accounted for 86 million tons; industry, 23 million tons; power generation contributed 20 million tons; space heating, 8 million tons, and the remaining 5 million tons came from refuse burning. The greatest quantity of any single pollutant was carbon monoxide, 73 million tons; next was sulfur dioxide at 27 million tons; hydrocarbons contributed 18 million tons; particulates 13 million tons and finally, oxides of nitrogen accounted for 11 million tons.

Figure 1— *The various forms of transportation account for approximately 60% of the air pollution emitted in the United States.*

Figure 2 *Power plants sometimes emit large quantities of steam and pollutants into the air.*

Research conducted in many different locations and over many years has shown that excessive concentrations of certain pollutants cause harmful effects on humans and animals, many kinds of plants, and materials such as metals, stone, wood, leather, glass, paper, rubber and others.

That air pollutants can kill human beings has been tragically demonstrated a number of times in what are called air pollution episodes. Air pollution episodes take place when toxic pollutants are released under certain meteorological conditions, often combined with geographic and topographic factors, which prevent their dispersion over a period of several days. Slowly these poisons build up in the stagnant air until a concentration is reached which is lethal to many susceptible persons. These episodes have taken place again and again. Only in comparatively recent years have attempts been made to study and document these incidents. Thus studies have been made of episodes in the Meuse Valley, Belgium, in 1930; Donora, Pennsylvania, in 1948; London, England in 1952 and 1962; and New York in 1953, 1962, 1963 and 1966. The worst single air pollution disaster of those mentioned was the episode which took place in London in December 1952. Statistical analysis of mortality data during this period revealed that 4,000 people died as a result of air pollution. Undoubtedly, air pollution episodes have taken place many other times and places in addition to these documented instances.

Figure 3 *Large industrial plants can discharge hundreds of tons of air pollutants each year.*

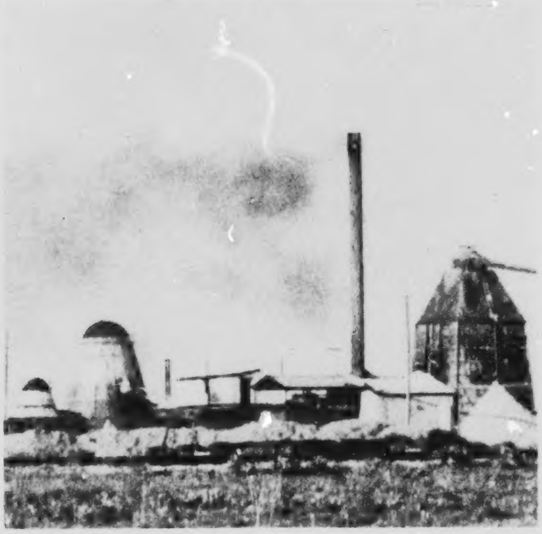

Figure 4 *The teepee burner is obsolete due to the difficulty of controlling combustion conditions.*

Fortunately, the technology which created the problems of air pollution has also provided solutions to many of these same problems. The successful resolution of the air pollution dilemma, then, is primarily one of economic and attitudinal motivation.

There are encouraging signs of a public desire to clean up the environment. These signs began showing up in the 60's and were reflected by an increase in legislation at the federal, state and local levels designed to deal with problems created by environmental pollution of all kinds. Specifically, the passage of the Clean Air Act in 1963 updated the original federal air pollution control act passed in 1955. It also increased the responsibilities of the federal government in the area of research and funding of air pollution control programs, while reaffirming the importance of state and local responsibility for control activities.

In 1967 the Air Quality Act was passed. This legislation represented a new approach to air pollution control in that it dealt with air pollution problems on a regional or interstate basis. The "Clean Air Amendments of 1970", P.L. 91-604, was a further step toward reducing atmospheric contaminants. Using data developed under the 1967 law, the Environmental Protection Agency was empowered to set national ambient air quality and emission standards based on available air quality criteria and control technology. The 1970 law also contained provisions for monitoring air quality to determine whether ambient standards are being met.

The increase in public awareness of the urgent problems of air pollution has led to a great increase in legislative and administrative activity. This in turn will lead to greater research and control activities, and intensify demands for trained technical manpower, both in the public control agencies and in private industry.

PREDICTION OF TECHNICIAN NEEDS

One of the most comprehensive investigations attempting to estimate future air pollution technician needs is contained in a report titled "Manpower and Training Needs for Air Pollution Control." This report was directed to the President and Congress by the Secretary of HEW in June, 1970. Using a predictive manpower model developed by EPA personnel, it was estimated that total manpower needs by state and local control agencies would number 8,000 by 1974. Slightly fewer than 400 technicians were employed full time in 1969. This number was expected to grow to nearly 1,000 technicians by 1974.

In the private sector, the survey estimated an increase from approximately 1,656 technicians in 1969 to 6,344 in 1974 — an increase of 380%. Significantly, the industries surveyed expressed no concern over the future supply of engineers and scientists. They were concerned, however, over what they saw as an increasingly acute shortage of technicians.

Figure 5 These technician trainees are getting field experience in source sampling.

Thus, according to this report, by 1974 there will be required by the Federal, state and local government and private industry some 5,700 new air pollution control technicians, assuming those presently working are still serving in that capacity.

A nation-wide manpower survey of 264 air pollution control agencies by EPA in April, 1971 revealed that: "The 1974 target of 8,000 full-time positions (reported in the 1970 survey) is a conservative estimate, since the model did not take into consideration the 1970 Amendments to the Clean Air Act which place an even greater workload on the control agencies than did the 1967 Act."

It is suggested that institutions considering training programs such as the one presented in this guide make full use of the most recent manpower projection studies available.

GENERAL CONSIDERATIONS

The objective of the total program recommended in this guide is to produce a competent air pollution technician. The technician must be capable of working and communicating directly with engineers, scientists and other personnel; of satisfactorily performing work for his employer; and of growing into positions of increasing responsibility. In addition, the graduate technician should have a beginning basis for becoming an active, well-informed member of society.

A program, which, when mastered, will produce the type of graduate described above, must be carefully designed. Each course must be planned to help the student develop knowledge and skill in its particular area and be directly integrated into the program. The sequence of courses, each of which is specially constructed, contributes toward the final objective of producing a competent technician. If close correlation of courses making up the program is not maintained, the program will not enable the student to obtain an understanding at the depth required of modern air pollution control technicians.

The technical content of the program is intended to supply a wide educational background in the diverse areas of applied air pollution technology. In the first year, the student should acquire an understanding of the history of air pollution, and social, economic, health and technical implications. In addition to basic air sampling methods and analysis techniques, he should also gain insight into problem solving through studies in technical mathematics, physics and chemistry.

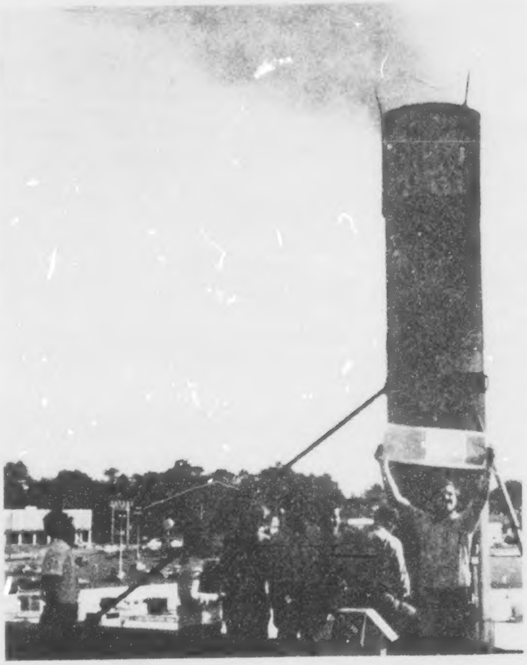

Figure 6. Use of the Ringelmann Chart for estimating emissions will probably decrease as more sophisticated sampling methods are developed.

The second year provides training at a higher level, including air pollution instrumentation, fundamentals of meteorology and advanced air sampling and analysis techniques. During this period, the student also receives instruction in the basic problems of wastewater treatment or solid waste disposal.

Graduates of the Air Pollution Technology program can expect to find employment in many areas of the air pollution control field. Each area may require somewhat different abilities and specialized knowledge and skills for a successful career. Most graduates will continue to develop their abilities through study on the job or in part-time study to master the specifics of a particular field. The following list indicates some of the major areas or clusters of job opportunities for air pollution technicians as described by employers. Some are beginning jobs; others are attained by experience and study on the job.

1. *Air Pollution Lab Technician*— A technician primarily concerned with the laboratory analysis of effluent and ambient air samples. He uses both wet chemistry and instrumental techniques and prepares reports based on his analyses.
2. *Air Pollution Field Specialist* — This technician performs both effluent and ambient testing procedures. He is familiar with different types of control equipment and knows how and where to take representative samples.
3. *Instrument Specialist* — A technician who performs duties involving the calibration, installation and maintenance of various types of air monitoring and measuring instruments.
4. *Inspector* — This technician is engaged in the registration and inspection of potential sources of air pollution. He detects and reports violations of air pollution control laws and regulations. He collects evidence of violations, conducts interviews with complainants and witnesses and may testify before judicial and semi judicial bodies.
5. *Technical Representative* — A technician employed by a firm as a sales and service representative for its products. He advises the customer and is capable of installing, operating, and servicing equipment. He may also train the customer's personnel to operate and maintain the equipment.

In addition to technical skill, some of the preceding jobs call for particular personal traits. For example, the inspector and the technical representative must possess the ability to meet and deal with the public. Highly skilled technicians must be capable of working closely with engineers, scientists and other technicians and of supervising and coordinating the efforts of skilled workmen.

Technician education programs develop highly specialized persons who must be able to perform many tasks requiring special skills and who must approximate the professional in education, attitude and competence. Such programs provide for rigorous study of scientific principles and supporting mathematics and for intensive laboratory and field practice oriented to instruction. Programs must provide students opportunities to gain (1) knowledge of applied scientific principles and of equipment, industrial and other energy processes, techniques, materials and instruments, and (2) the ability to communicate with engineers and scientists, and to serve as delegates or assistants to such persons. Although some technical and comprehensive high schools provide for technical and related vocational education, intensive programs such as described herein are more generally suited for two years of post high school study.

Some indication of the special nature of engineering technician programs can be obtained from an analysis of what technicians must know, what special abilities they must possess and what they must be able to do in their work.

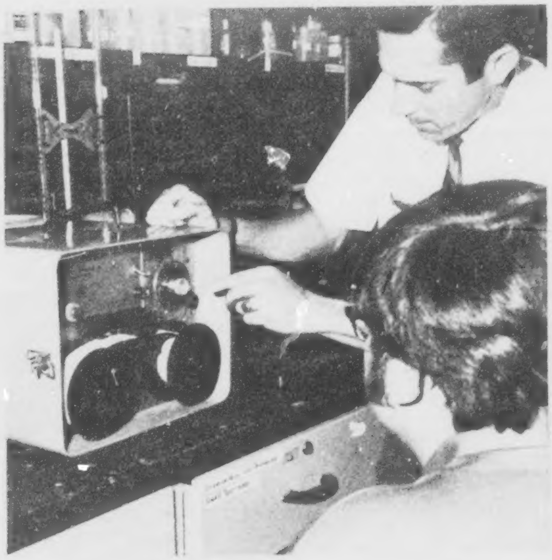

Figure 7 — *An instructor demonstrating the use of the tape sampler, which measures the soiling properties of the air.*

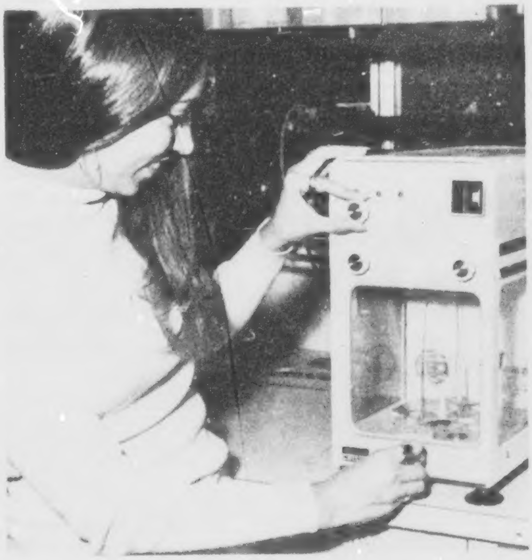

Figure 8 — *Good employment opportunities for women exist in the air pollution control field.*

SPECIAL ABILITIES REQUIRED OF TECHNICIANS[1]

Technicians must have the following special abilities:

1. Proficiency in the use of disciplined and objective scientific method in practical application of the basic principles and laws of physics and chemistry and/or the biological sciences as they constitute the scientific base for the individual's field of technology.
2. Facility with mathematics: ability to use algebra and trigonometry as tools to develop, to define, or to quantify scientific phenomena or principles; and, when needed, an understanding of, though not necessarily facility with, higher mathematics through analytical geometry, calculus, and differential equations, according to the requirements of the technology.
3. A thorough understanding of and facility in the use of the materials, processes, procedures, and equipment commonly used in the technology.
4. An extensive knowledge of a field of specialization, with an understanding of the underlying physical or biological sciences and their application to the engineering, health, or industrial processing or research activities that distinguish the technology of the field. The degree of competency and the depth of understanding should be sufficient to enable the individual to establish rapport with the engineers, scientists, managers, or researchers with whom he works, and to enable him to perform a variety of detailed scientific or technical work using general procedures or instructions but requiring individual judgment, initiative, and resourcefulness in the use of techniques, handbook information, and recorded scientific data.
5. Communication skills that include the ability to record, analyze, interpret, and transmit facts and ideas orally, graphically, and in writing with complete objectivity.

ACTIVITIES PERFORMED BY TECHNICIANS[2]

A technician must perform a variety of functions. He must be prepared to:

1. Apply knowledge of science and mathematics extensively in rendering direct technical assistance to engineers or scientists engaged in air pollution control, monitoring or research.
2. Design, develop, or plan modifications of new products and techniques or processes under the supervision of scientific, engineering, or medical personnel in applied research, design, and development.
3. Help plan, supervise, or assist in installation; and inspect complex scientific apparatus, operation, equipment, and control systems.
4. Advise regarding the operation, maintenance, and repair of complex equipment with extensive control systems.
5. Advise, plan, and estimate costs as a field representative of a manufacturer or distributor of technical equipment and/or products, or services.
6. Assume responsibility for performance or tests of mechanical, hydraulic, pneumatic, or electrical components or systems in the physical sciences; and/or for determinations, tests and/or analyses of substances in the engineering or health-related sciences, and the preparation of appropriate technical reports covering the tests.
7. Prepare or interpret engineering drawings and sketches, or write detailed scientific specifications or procedures for work related to the physical or engineering sciences.
8. Select, compile, and use technical information from references such as engineering standards, handbooks, biological, or health-related procedural outlines; and technical digests of research findings.
9. Analyze and interpret information obtained from site inspections, and make evaluations upon which technical decisions are based.
10. Analyze and diagnose technical problems that involve independent decisions. Judgment must be based not only on technical know-how but on substantive experience in the occupational field as well.

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[1] Adapted from *Occupational Criteria and Preparatory Curriculum Patterns in Technical Education Programs* (OE-80015), U.S. Office of Education, Washington, D.C. 20202.

[2] Ibid.

11. Deal with a variety of technical problems which must be solved by a person with an understanding of several technical fields. Such versatility depends on broad experience in applying scientific and technical principles, the antithesis of narrow specialization.

A two-year program to educate air pollution technicians must concentrate on primary or fundamental needs if it is to prepare students for responsible positions in modern technology. It must be realistic and pragmatic. The program suggested in this guide has been designed to provide maximum technical instruction in the time that is scheduled.

To those who are not familiar with this type of educational service (or with the goals and interests of students who elect it), the technical program often appears to be inordinately rigid and restrictive. While modifications may be necessary in certain individual institutions, the basic structure and content of this program should be maintained.

The specialized technical courses in the program are laboratory and field oriented. They provide time for the application of the scientific principles concurrently being taught in the courses in physics, chemistry and mathematics. For this reason, mathematics and science courses must be coordinated carefully with technical courses at all stages of the program. This coordination is accomplished by scheduling mathematics, science, and technical courses concurrently during the first two terms, a principle that will be illustrated at several points. General education courses constitute a small part of the total program. It has been found that students who enter a technical program do so because of the depth of specialization that the program provides. Experience shows that many students who elect this type of program bring to it a background of general study.

FACULTY

The effectiveness of the program depends largely upon the competence and the enthusiasm of the teaching staff. The specialized nature of the program requires that the teachers of air pollution technology subjects have special competence based on proficiency in technical subject matter and industrial or agency pollution control experience. It is important also that all members of the faculty understand the educational philosophy, goals, and unique requirements that characterize this program.

To be more effective, members of the faculty responsible for this program must have interests and capabilities which transcend their areas of specialization. All of the faculty members should be reasonably well informed of the requirements for study in air pollution control practices so that they may use field examples or subject matter as supporting material in teaching. For example, if the control equipment courses are to be of maximum value, the teacher must be familiar with the equipment in present use, its applications and limitations. Without such a background, the teacher cannot give course work the support that is needed in the total program of education for the technicians. Similarly, various scientific principles may be taught in courses in physics and mathematics, and the course instructors should emphasize the principles by illustrating their applications.

Teachers of specialized technical subjects require advanced technical training. Although in the past many teachers have been recruited from industry, control agencies and engineering professions, recent experience has shown that graduates of technician training programs who have acquired suitable experience and who have continued their technical and professional education often become excellent teachers in this type of program. Such persons are likely to understand the objectives and unusual instructional requirements of technical education. Furthermore, persons with this particular background often bring to the program an enthusiasm for and an appreciation of the values of technical education—characteristics that are essential to the success of any education program.

Another possible source of teaching personnel is the Air Pollution Control Employment Bulletin, published by Ability Search, Suite 202, Davis Building, 1629 K Street N.W., Washington, D.C. 20006. This publication, issued monthly, lists people with various educational backgrounds but with training in some aspect of the air pollution field who are seeking employment.

Since programs for highly skilled air pollution control technicians must be a series of well-integrated courses if the scope and depth of training given are to be adequate, careful consideration must be given to when and at what level a new concept is to be introduced. This may be accomplished through "team teaching." In this sense, team-teaching is the organization of a technical staff into a coordinated teaching unit. Teaching assignments are made on the basis of the individual member's special training and talents. Concurrent courses are closely coordinated by team members to best utilize the student's time while he is moved smoothly on to progressively higher levels of understanding.

"Team teaching" can be developed and nourished only by the teaching faculty. A weekly departmental staff meeting to encourage the development of "team-teaching" is recommended. At these meetings, each instructor should check with instructors of concurrent courses to insure that courses are being coordinated. This is especially important when new courses or new techniques are involved. If less optimum coordination is evident, the team can analyze the problem and quickly find a solution.

In addition to keeping concurrent courses well coordinated, staff meetings provide for free exchange of ideas on teaching techniques discovered to be useful, and on recently developed laboratory projects which seem to be particularly successful. Any project which seems especially interesting and beneficial to the student should be analyzed to see whether the same principles of presentation can be employed in other projects. Furthermore, the meetings provide for discussion of scientific or technical journal articles which may improve the teaching of a subject or which present new information which should be taught.

The most competent faculty member will never feel that he has completely mastered his special area of expertise. Throughout his professional career he will be on the alert for new methods, materials, and equipment. He will continue to read, to study, to maintain contact with the changing concepts of air pollution control and to visit agency and industrial control programs. In brief, he will not attempt to teach tomorrow's practices to today's students if he has only yesterday's knowledge.

The institution must try to bring the most competent instructors into the classrooms. It should attempt to employ instructors with both technical qualifications — such as professional engineers and engineers with industrial backgrounds — and proved teaching ability. It may well consider seeking instructors "on loan" from public control agencies and industrial firms or employing specially qualified instructors part-time or as guest lecturers. It must always encourage its full time faculty members to upgrade their professional qualifications.

To help keep a staff effective, an institution should encourage faculty members to participate as active members of professional and technical societies. Through such organizations they can keep up with new literature in the field and maintain closer liaison with employers of technicians or other leaders in the field. By attending meetings they can hear addresses by outstanding specialists in the field. Technical school administrators are increasingly encouraging the self development of staff members by providing released time and financial assistance to those who attend society meetings and technical teacher-training institutes. Periodic or sabbatical leaves should be offered to allow staff members a chance to increase and update their industrial experience, or for further study.

When determining teaching loads for teachers of technical specialty courses, administrators should consider the number of student contact hours required by their schedules. Fully effective instructors in this field require considerably more time to develop courses and laboratory materials than do shop instructors teaching vocational skills, or teachers of general education courses. A contact-hour workload of from 15 to 20 hours a week usually constitutes a full teaching load for technical specialty teachers. The rest of their time should be spent in assisting students and in developing courses and effective laboratory experiments.

Class size must be considered in developing effective teaching, since the individual attention is recognized as a vital element in teaching. The maximum size of a lecture class may vary somewhat, depending on the material to be covered, the lecture room, and the teaching techniques used; but for blackboard lecturing, class sizes of from 20 to 30 students usually should be considered optimum. If little or no class discussion is attendant to the lecture and if the parts of the lecture normally written on the blackboard are carefully prepared and presented by an overhead projector, the size of the class may be significantly increased.

Careful planning of laboratory teaching is important. Laboratory sections should not be overloaded with students. Teaching cannot be effective if there are too many students per workgroup or if too many different experiments are being conducted simultaneously in the same laboratory. If too many students try to work on a project, most of them will not benefit from the experiment, because they cannot participate sufficiently in doing the work. An optimum group size is usually two students per laboratory setup, although some experiments can be effective for groups of three or even four. If too many experiments are underway, the laboratory instructor cannot be effective, and the laboratory experiments cannot be closely coordinated with theory lectures.

Technical programs are designed to produce supporting employees who increase the effectiveness of engineering teams. The same principle of assistance may be employed to increase the effectiveness of the teaching staff.

Figure 9.—Students calibrating a high-volume sampler blower in the laboratory.

Figure 10.—The filter on the right shows the amount of dirt removed from an air sample in 24 hours.

Staff assistants may be used in stock control to set out the proper equipment for laboratory classes, to keep equipment operating properly, to fabricate training aids, and to do a limited amount of routine paper grading. When assistants do these important but time-consuming jobs, the teaching staff can devote more time to developing courses, preparing handouts to supplement lecture material, and insuring that necessary components and properly functioning equipment will be available when needed. Resourceful use of supporting personnel makes it possible to have a small but versatile staff which may be maintained as enrollment varies. By adjusting the size of the supporting staff to the demands of enrollment, a school may at least partly solve the problem of having too few instructors when the enrollment is high and too many instructors if the enrollment is reduced. Most of the supporting staff members may be recruited from the student body or graduates from the program.

STUDENT SELECTION AND SERVICES

Since the ultimate objective of the program is to produce high-quality graduates, it is essential that the students accepted into the program have certain capabilities. If the incoming student's background is inadequate, the instructors will tend to compromise the course work to allow for the inadequacies, with the probable result that the program will be inadequate in depth and scope.

Students chosen for this program should have similar backgrounds and capabilities and should exhibit some evidence of maturity and seriousness of purpose; otherwise the program might not achieve its objectives. Wide ranges of ability among students can create an inefficient teaching situation and thereby prevent the program from progressing at the necessary rate. The amount of material to be presented and the principles to be mastered require students who not only are well prepared in formal course material but also have the ambition, desire, and will to master a difficult program and to develop their capabilities to the limit.

The program is designed for high school graduates who have particular abilities and interests. In general, students entering the program should have completed a minimum of 2 years of high school mathematics, including algebra and geometry, and 1 year of physics, or chemistry with laboratory experience, or the equivalent.

The ability levels of those who do, and those who do not, meet these general requirements will vary greatly. If a student enters a program without adequate preparation, he will usually fail; if a class, or majority of a class, begins without the requisite preparation, the program cannot prepare highly capable technicians, and to that extent the program will fail. If applicants for admission do not have the necessary mathematics, science, or language skills, they should take remedial work before entering the technical program. If possible, this remedial work should be offered at the school where the applicant plans to enter a technical program.

Many institutions which offer programs for technicians provide pretechnical programs up to a full year's duration to give promising but under-prepared students the opportunity to enter a technical program of their choice with a good probability of successfully completing it. A pretechnical program helps solve student recruitment problems, provides assurance of high quality of graduates by starting with adequately prepared students, and gives promising students an opportunity to educate themselves to meet the nation's urgent need for technicians.[1]

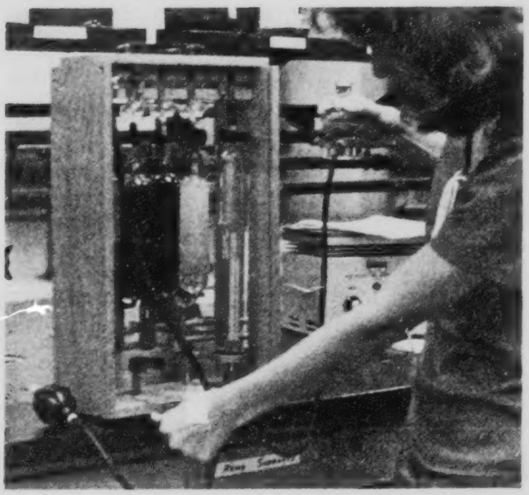

Figure 11 *This gas analyzer tests samples for carbon monoxide, carbon dioxide and oxygen content. Technicians must develop a facility for using such equipment.*

Effective guidance and counseling are essential. The student should be aided in selecting educational and occupational objectives consistent with his interests and aptitudes. Whenever possible, institutions offering technical programs should consider the use of standardized or special tests to assist in student selection, placement, and guidance. A student should be advised to revise his educational objectives if it becomes apparent that he lacks interest in the technical program or lacks ability to complete the program satisfactorily.

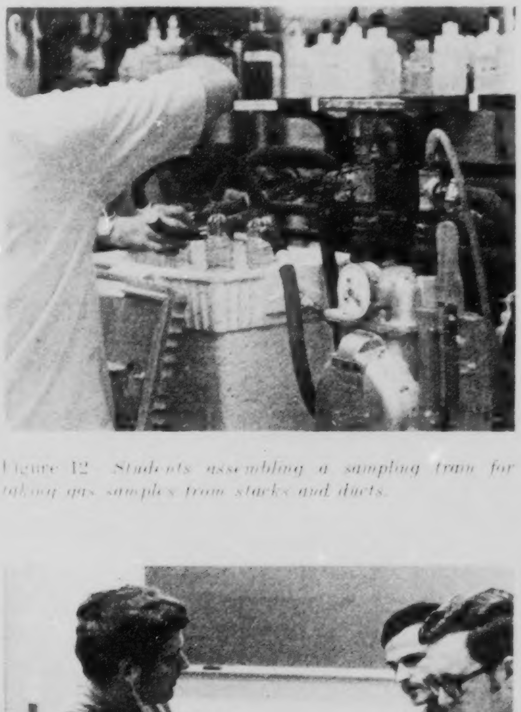

Figure 12 *Students assembling a sampling train for taking gas samples from stacks and ducts.*

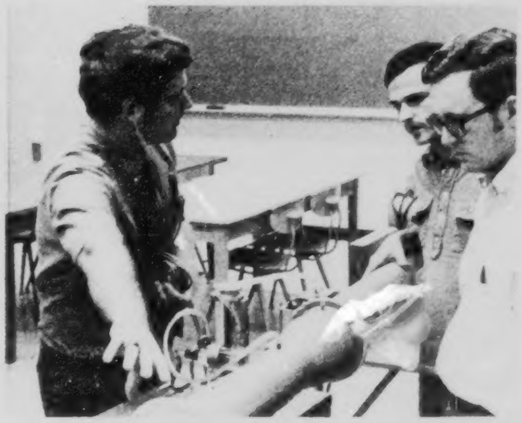

Figure 13 *The principles of a venturi gas measuring device must be thoroughly understood by technicians.*

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[1] U. S. Department of Health, Education, and Welfare, Office of Education. *Pretechnical Post High School Programs: A Suggested Guide.* OE 80049. Washington: Superintendent of Documents, U.S. Government Printing Office, 19[illegible].

The new student should quickly become familiar with the facilities on campus. In particular he should be given a tour of the library facilities and be made familiar with the procedures and rules governing the use of the library. If possible, organized field trips to nearby industries and control agencies should be arranged early in the program to give new students an opportunity to see air pollution technicians on the job. These tours may provide motivation and perhaps point out why certain required subjects are important.

A departmental student organization may be formed to help bring together people with similar interests. The meetings of this organization should provide exercise for the students in arranging their own technical programs. Speakers from control agencies and industry or selected films may be used to stimulate interest at meetings. Student organizations may assist with and participate in department activities such as "career days" and "open house" events.

Students should be given information concerning student membership in technical societies and be encouraged to join such societies. Student chapters of professional societies offer an opportunity for the student to receive excellent material on a regular basis at nominal costs, and to associate with professional people in his field at meetings. After graduation, the technician may find affiliation with a society and regular reading of journal articles an important method of keeping his technical knowledge current in the field.

As their graduation approaches, students should be made aware that some tasks open to technicians may be licensed or certified and that certification may be important for their future employment. To the extent permitted under state licensing requirements, students should be encouraged to get certification or other licenses as quickly as possible.

The academic achievement of students should be recognized in some manner. Many institutions grant graduates an associate degree as tangible recognition of achievement. A departmental club might present an annual award to an outstanding graduate. Private companies might offer to contribute to an annual scholarship award.

Graduates of technical programs should be aided in every way possible in finding suitable employment. Placement officers should be aware of the needs of the region's control agencies and industry for technicians and should acquaint prospective employers with the qualifications of graduates. The placement function is an extremely valuable service to the student, the institution, and the employers. In the final analysis, the placement of graduates is an important responsibility, which is directly or indirectly the concern of the department head of the instructor who teaches the technical specialty. An excellent placement record is important in getting new students. In addition, the school should conduct periodic followup studies of its graduates to determine their progress and to evaluate their training. Many times such studies can indicate how the program or teaching techniques can be improved.

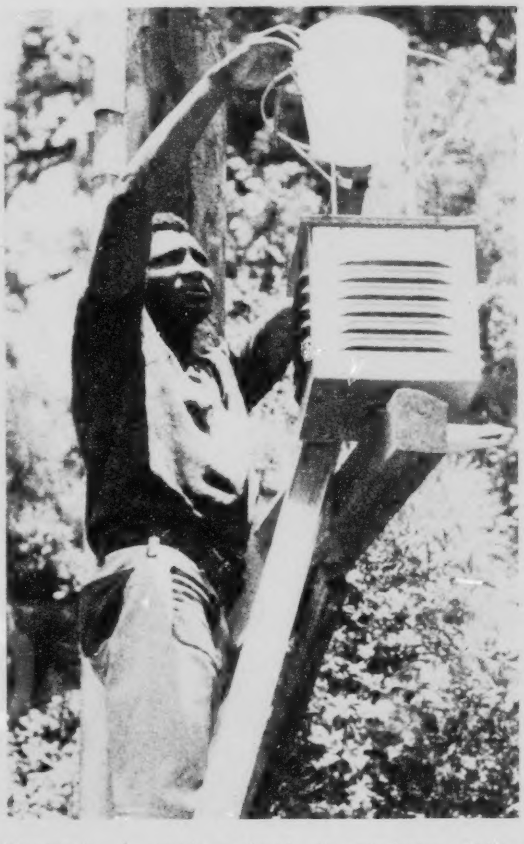

Figure 11 *A simple ambient air monitoring station provides background information on the cleanliness of the air.*

TEXTBOOKS, REFERENCES, AND VISUAL AIDS

Textbooks, references, and visual aids for teaching any technology must be reviewed constantly and supplemented in the light of (1) the rapid developments of new knowledge in the field, and (2) the results of research in methods of teaching and developing basic concepts in the physical sciences and mathematics. This is especially true in the field of pollution control technology. The development of whole new areas of theoretical and applied scientific knowledge is demanding new textbooks, new references, articles in scientific and technical journals, and new visual aids materials.

New textbooks will reflect recent methods of teaching scientific principles and applications as fast as current research in education becomes applicable. Recent extensive research in methods of teaching mathematics and physics certainly will produce changes in teaching material and methods. It is therefore mandatory that instructors constantly review modern texts, references, and visual aids materials as they become available and adopt those that are an improvement over the ones suggested at the end of each course outline.

The suggested texts and references have been carefully selected; however, there is a scarcity of good texts at the technician level in air pollution technology education.

Before a department head or instructor undertakes a program in air pollution technology or any course contained in the program, he should familiarize himself with the texts and references listed here and others which are available. He will then be able to select the text which best serves his particular needs in making a lucid, high level technical presentation to his students.

Visual aids can be of great help in teaching programs. The aids which are noted here have been selected from an extensive list and represent those considered most suitable at the time the curriculum was prepared. Many are not listed, because the variety and extent of the materials make an all-inclusive listing prohibitive. From those listed and others available and pertinent, an instructor may select visual aids which meet his teaching objectives. He should *always* preview and study visual aids before using them in teaching.

LABORATORY EQUIPMENT AND FACILITIES

Laboratories and equipment for teaching air pollution technology programs must meet high standards of quality, since the objectives and the strength of the programs lie in students getting valid practical experience, basic in nature and broad in variety. Well-equipped laboratories with sufficient facilities to enable all students to work in the laboratory are required for the courses. The student's training program should include experiences which illustrate the function and application of a wide variety of standard tests and functional systems and their representative uses.

Variety and quality of equipment and facilities are more important than quantity in equipping laboratories. Laboratory equipment and facilities are a major element of the cost of such a program, but they are indispensible if the training objectives are to be met.

Equipment must be of good quality if laboratory work is to offer the student valid experiences. Inferior equipment may not show the principles being studied or may not be sensitive enough to provide reliable or precise data. Such equipment may require unreasonable amounts of time and expense for repairs or adjustment. The initial cost of high quality equipment is usually greater than that of low quality, but the difference in cost is justified because it makes possible laboratory experiments that give precise results.

In the selection of laboratory equipment, the need for each item should be well established. Expensive apparatus may not always be required. Many significant experiments can be made with relatively inexpensive components. In fact, in many cases these components can make it easier for the student to understand the principles because they present only the essentials. The number of units purchased, the particular areas of interest, the particular industry emphasis, and the ingenuity of the instructors in adapting equipment to teaching needs will in part govern the selection and cost of laboratory equipment. Throughout the program, the emphasis should be on the principles which serve as the basis for solving many different kinds of air pollution problems.

A recommended approach to developing laboratory work and equipping the laboratories is to determine what experiments and experiences are needed for each course and then to design the exercises, so far as possible, using standard components and equipment which are representative of those currently being used in the industry or in related government control agencies. This approach requires staff time and effort; but because the experimental equipment has been assembled to demonstrate some principle or to make a specific experimental determination with clarity and precision, it usually accomplishes the best teaching. Laboratory equipment and facilities are discussed in more detail in a later section, entitled "Facilities, Equipment, and Costs."

THE LIBRARY

In any evaluation of a technology program, its strength is indicated by the quality of its library. It is indicated by the qualifications of the librarian; the facilities, the quality, quantity, and relevancy of content; and the staffing and organization of the library.

Dynamic developments causing rapid changes in technological science and practice make it imperative that the student learn to use a library. Instruction for technical students should therefore be library oriented so that they may learn the importance of being able to find information on any of the various courses they are studying. They should form the habit of using the library as a tool in learning. This knowledge helps students develop a professional attitude and further teaches them to depend on libraries to keep abreast of new developments.

Instructors of all courses should inform their students that library use is an important part of the program. Planned assignments that require the use of the library to prepare reports on pertinent subjects will enable students to understand the resources available and their relation to technology. Open-book examinations that require use of the library provide excellent and objective experiences. Under the incentive of the examination and the pressure of time, students obtain a clear understanding of their own competency in using the library.

The growth and success of the graduate technician will depend largely on his ability to keep up with changes in his field.

For this reason a central library under the direction of a professional librarian is important to the success of the technology program. Most instructors have private libraries in their offices from which they may select books of special interest to discuss in their personal conferences with students and thereby stimulate their interest in related literature. However, a central library insures the acquisition and cataloging of the library content according to accepted library practices and provides systematic card files, which facilitate the location of reference materials. It also provides a controlled and orderly system for lending books to students typical of those in libraries which they might use as employed technicians. Provisions for lending materials for out-of-library use should be systematic and efficient. Suitable study space should be provided students for use of references.

The head librarian usually reports to the top administrative officer of the school and has full faculty status. The American Library Association (ALA) standards state: ". . . two professional librarians are the minimum number required for effective service in any junior college with an enrollment up to 500 students (full-time equivalent). In addition, there should be at least one nonprofessional staff member. The larger the institution, the more appropriate it will be to employ a higher proportion of nonprofessional staff members."

According to ALA, the library budget should be determined in relation to the total budget of the institution for educational and general purposes, but the amount to be allocated to the library should be based upon a program of optimum library service in support of the school's goals. The execution of the library program, as it is outlined in the ALA standards, normally requires a minimum of 5 percent of the total educational and general budget. This minimum percentage is for a well-established library with an adequate collection. It would have to be increased if there were a rapid increase in the student body or in course offerings; it would again need to be increased if the library were made responsible for an audiovisual program. The library budget for a newly organized institution should be considerably higher than 5 percent.

Another ALA criterion for the library budget is that the funds for acquiring new library materials should equal or exceed the total of salaries for the library staff. This is for established libraries; the expenditure for acquisition of new library materials should be substantially greater for libraries which are just starting or making major additions to programs.

A library must provide adequate literature containing the information encompassed by all subjects in a program and extending somewhat beyond the degree of complexity or depth of that students cover in classrooms. Literature dealing with unusually highly specialized aspects of a subject may be acquired as needed or may be borrowed by the librarian from more comprehensive libraries.

The library content should meet the needs both of full-time students and of the part-time students' supplemental courses to upgrade or update their occupational knowledge and skills. In addition, it should serve the day-to-day needs of the instructors as they keep their own technical knowledge abreast of the new developments pertinent to their special field of applied science.

In view of the highly specialized nature of library content for air pollution technology, the department head or chief instructor of the technology should be a member of the library committee and should be responsible for approving the reference material selected for the technology and related courses. The librarian, as chairman of such a committee, may be expected to take the initiative in calling meetings or informally consulting with the head of the air pollution technology department so that within the limitations of the budget and the consideration of total library needs, the department will acquire the appropriate library content.

The teaching staff and the library staff should cooperate in determining what materials are to be acquired and should be responsible for the final selection of the materials that support their technical courses. They must take the initiative in recommending materials to keep the library current, pertinent, and useful. The library staff should supply the teaching staff with a periodic list of recent acquisitions complete with call numbers. Technical and trade journals should either be circulated among the teaching staff or be placed in a staff reserve section for a short time before they are made available for general library use.

In addition to reference materials, journals, and trade publications, a library should have encyclopedias available for quick reference and should maintain index material such as the *Engineering Index* and the *Applied Science and Technology Index* to aid staff and students in finding recent material on specific subjects. If visual aid materials are centered in the library, they should be reviewed and evaluated by both the librarian and a member of the teaching staff as they become available. This procedure will inform the teaching staff of what visual aids are available and where they may be used best in the technical program.

A well-equipped, modern library should have some type of duplicating service available so that copies of library materials may be easily obtained by students and staff. Such a service allows both students and staff to build up-to-date files of current articles appropriate to the courses in a program. The service should be available to the students at a minimum cost and free of personal cost to the teaching staff.

Further suggestions and discussion of library content for the technology are provided in Appendix A.

Figure 15. *The general lack of care at this small plant contributes a detrimental effect on the environment.*

SCIENTIFIC AND TECHNICAL SOCIETIES

Scientific and technical societies[4] and trade associations are an important source of instructional materials and other benefits for faculty members and students. Such societies provide, through their publications and meetings, immediate reports and continuing discussion of new concepts, processes, techniques, and equipment in the physical sciences and related technologies. The presentation and interpretation of scientific and technical discoveries explain the relationship of the theoretical scientist's work to the applied science practitioner's requirements. They are an invaluable aid in keeping abreast of new developments in a particular phase of science.

Less conspicuous, but extremely important, is the support which some societies may give (1) in helping to develop evidence of need for a training program, (2) in helping to promote the program, (3) in enlisting members' support for the program, (4) in helping to provide work experience for students, and (5) in helping with the placement of graduates.

Associations and societies may supply resource people to speak to classes. They may also serve as hosts to student groups on field trips to study specific phases of the technical area.

Instructors should be encouraged to become active members of these societies so that they may learn quickly of new technological developments. Membership will also enable them to meet people in the community who are most actively interested in the field. Some educational institutions pay all or part, of the costs of membership dues and attendance at local or national meetings in order to encourage staff participation in selected societies.

Early in their studies, students should be required to become acquainted with the literature and services of scientific, technical and engineering societies. They should also be encouraged to join those which offer affiliate memberships.

Many professional organizations and associations of manufacturers and producers serve the scientist, engineer, technician, administrator, teacher, student, and others dealing with the problems of air pollution. Some of these organizations are listed in Appendix B. For example, the Air Pollution Control Association plays a leading role in disseminating information on new air pollution control methods and techniques and publishing the results of basic research projects.

Some other scientific, technical, industrial groups, and agencies whose publications and services interest teachers and students of air pollution technology are:

Air Pollution Control Association
American Association for the Advancement of Science
American Chemical Society
American Industrial Hygiene Association
American Institute of Chemical Engineers
American Meteorological Society
American Society for Testing Materials
American Society of Civil Engineers
American Society of Heating, Refrigeration and Air Conditioning Engineers
American Society of Mechanical Engineers
Incinerator Institute of America
International Clean Air Congress
Los Angeles County Air Pollution Control District
National Bureau of Standards
National Council of the Paper Industry for Air and Stream Improvement, Inc.
National Environmental Health Association
National Sanitation Foundation
The Society of the Sigma Xi
U. S. Department of the Interior
U. S. Environmental Protection Agency
U. S. Government Printing Office
U. S. Public Health Service
Water Pollution Control Federation
World Health Organization

ADVISORY COMMITTEES AND SERVICES

The success of technician education programs depends, to a great extent, on the formal and informal support of advisory committees. When an institution considers the advisability of initiating a particular technological program, the chief administrator or dean should appoint the advisory committee.

The special advisory committee for the air pollution technology program should be comprised of representatives of employers and public regulatory agencies, scientific, or technical societies and associations in the field, engineers employed in industry and operating personnel, and knowledgeable civic leaders, who meet with and advise the specialists on the school's staff. Such members serve without pay as interested citizens. They enjoy no legal status, but provide invaluable assistance. The committee normally consists of about 12 members (but may range from 6 to 20), who generally serve for a 1- to 2-year period. The head of the institution or the department head of the technology is ordinarily chairman. Since such people are always busy, the meetings should be called only when committee action can best handle a specific task or problem.

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[4] U. S. Department of Health, Education, and Welfare, Office of Education. *Scientific and Technical Societies Pertinent to the Education of Technicians.* OE 800[illegible]. Washington: Superintendent of Documents, U. S. Government Printing Office, 1966

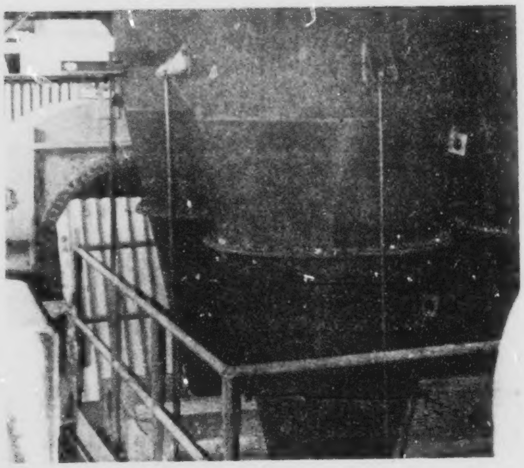

Figure 16. *Large cyclones remove heavy dirt particles from the discharge gases of a power boiler.*

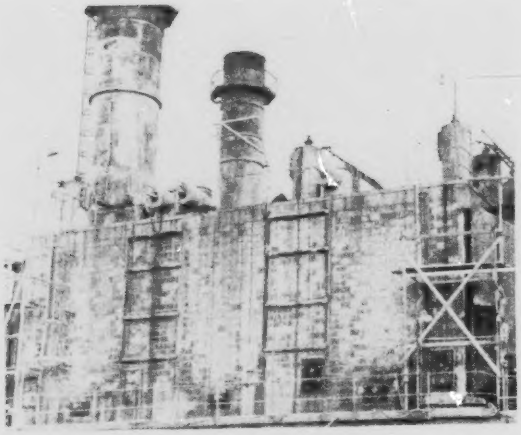

Figure 17. *Industrial electrostatic precipitators can handle thousands of cubic feet of gas per minute and remove over 99% of the particulates.*

The committee assists in surveying and defining the need for the technicians; the knowledge and skills they will require; employment opportunities; available student population; curriculum, faculty, laboratory facilities and equipment; cost and financing of the program. When the studies indicate that a program should be initiated, the committee's help in planning and implementing it is invaluable.

Frequently the committee substantially helps school administrators to obtain local funds and state and federal support for the program. When the graduates seek employment, the committee aids in placing them in jobs and in evaluating their performance. Such evaluations often will result in minor modifications, which more closely relate the program to employment requirements.

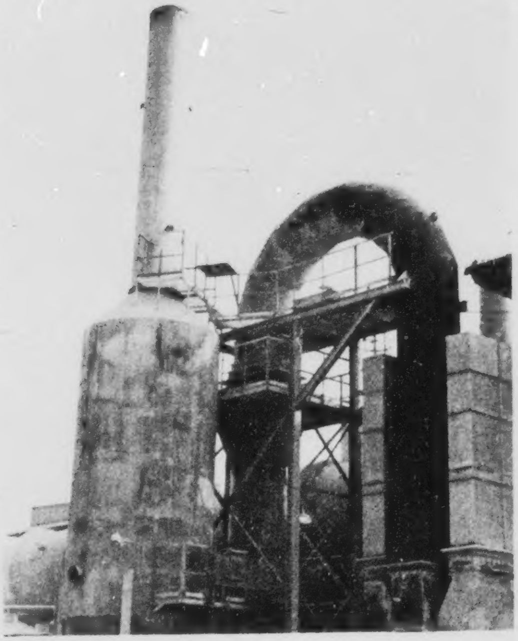

Figure 18. *A venturi scrubber and separator tank do an effective job of cleaning the gases from a lime kiln.*

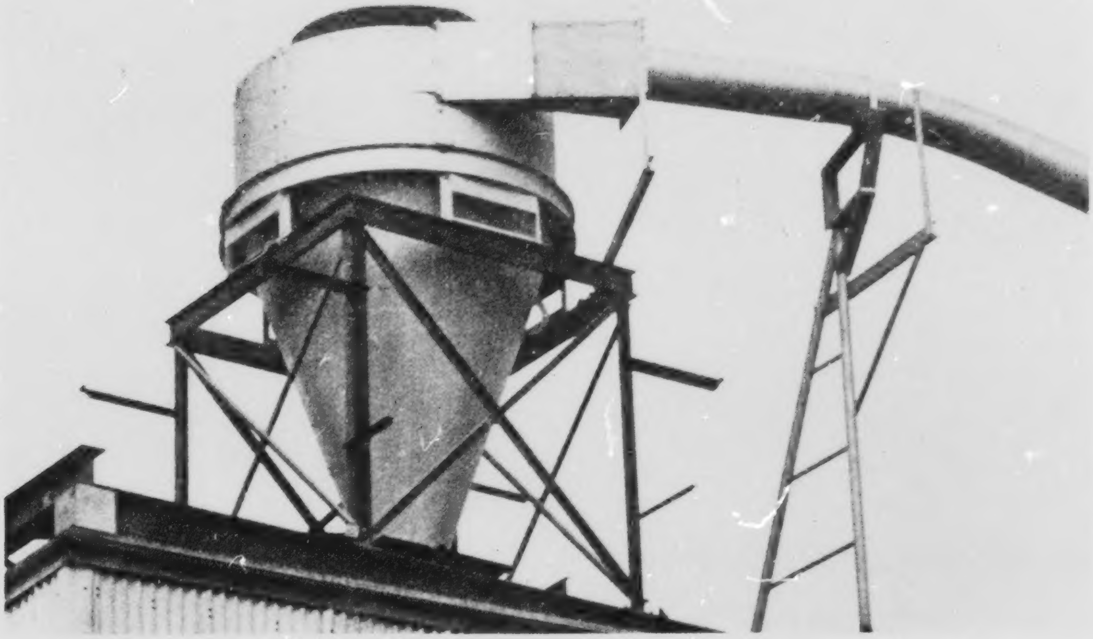

Figure 19 – A simple rooftop cyclone can efficiently remove heavy particulate matter from a discharge gas stream.

The advisory committee can use this guide, designed primarily for planning and development of full-time preparatory programs in post high school institutions, as a starting point and modify it to meet local needs. The program can also form the basis for courses to meet the requirements of employed adults who wish to upgrade or update their skills and technical capabilities. In this way the school administration, with the help of the committee and special consultants, can effectively initiate the needed program, quickly develop it to a high level of excellence, and maintain it timeliness.

Very likely this guide will be adapted to suit various situations in schools in differing localities. The assistance of an advisory committee and of special consultants has been found to be of much value in initiating and developing programs. The courses in guides such as this one have often been modified by schools and their advisers to serve employed adults who need to update or upgrade their skills and technical capabilities.

The program is not intended to make an individual student proficient in all the duties he might be asked to perform. Proficiency in highly specialized work will come only with practice and experience. It is impossible to forecast the exact requirements of the duties assigned to any technician, and it is almost impossible to predict accurately the course or rate of change of various technologies. Employers generally recognize that the recent engineering graduates may require a year or more to obtain the specific training they need and to orient themselves to their responsibilities and role in an organization. Similarly, employers of newly graduated air pollution technicians must generally expect to provide a three- to six-month period of orientation on the job. Furthermore, the productive graduate technician will continue to study throughout his career in order to develop to his fullest capabilities.

More detailed information on advisory committees and their functions is contained in the book "The Role of the Advisory Committee in Occupational Education in the Junior College" by Albert J. Riendeau, American Association of Junior Colleges, Washington, D.C. 1967.

THE CURRICULUM

Course Requirements

	Hours Per Week			
Course	*Class*	*Laboratory*	*Outside Study*	*Total*
First Semester				
Atmospheric Pollution	3	0	6	9
Air Pollution Sampling & Analysis I	2	6	4	12
Mathematics I	4	0	8	12
Chemistry I	2	3	4	9
Communications Skills	3	0	6	9
Total	14	9	28	51
Second Semester				
Air Pollution Sampling & Analysis II	2	6	4	12
Mathematics II	4	0	8	12
Chemistry II	2	3	4	9
Physics I	2	3	4	9
Technical Reporting	2	0	4	6
Total	12	12	24	48
Third Semester				
Sources of Air Pollution	3	0	6	9
Air Pollution Instrumentation	2	6	4	12
Physics II	3	3	6	12
Biology	3	4	6	13
Total	11	13	22	46
Fourth Semester				
Meteorology	1	3	2	6
Air Pollution Control	3	6	6	15
Air Pollution Sampling & Analysis III	2	6	4	12
Introduction to Wastewater Technology*	2	3	4	9
Industrial Organizations, Institutions and Government	3	0	6	9
Total	11	18	22	51

*Optional Alternate Course:
Principles of Solid Waste Management

Brief Description of Courses

Atmospheric Pollution

As an introduction to the air pollution problem, this course considers the classification of pollutants, and their effects on man, plants and materials. Also studied are legal aspects of pollution control administration.

Air Pollution Sampling and Analysis I

Basic air pollution sampling and analysis procedures with emphasis on ambient testing are studied. Dustfall, suspended particulates, oxides of sulfur, hydrocarbons, and other contaminants are considered in detail.

Mathematics I

This introductory course stresses application of the basic concepts of logic, sets, algebra, probability, analytic geometry and trigonometry to representative problems in air pollution. Attention is given to the construction and analysis of tables, flow diagrams and graphs.

Chemistry I

Selected fundamental concepts of chemistry and their practical application to the origin and control of air pollutants are studied in this first chemistry course. Experimental work stresses safety and accuracy in performing measurements and other laboratory techniques required of the air pollution technician. Lecture topics include the structure and properties of matter, periodic classification of the elements, chemical bonding, elementary stoichiometry, the gas state and atmospheric chemistry.

Communications Skills

This course is designed to increase competence in reading, writing and talking, and understanding oral instructions.

Air Pollution Sampling & Analysis II

This course concludes the study of ambient testing methods, and serves as an introduction to the basic methods of source sampling, including measurement and calculation of gas flow rate, humidity and psychrometry, ideal gas laws and their applications.

Mathematics II

The second math course is an extension of the concepts presented in Mathematics I, supplemented with an introduction to the differential calculus and a brief survey of basic computer programming. Statistical analysis and treatment of data are also introduced.

Chemistry II

The final course in this sequence continues the study of descriptive chemistry and its application to the origin and control of air pollutants. Experimental work includes a variety of analytical techniques. Lecture topics include the chemistry of solutions, typical properties and reactions of the element families, corrosion, nuclear chemistry, organic and biological chemistry.

Physics I

The basic principles of mechanical and thermal physics and their applications are considered here. Laboratory exercises stress applications to actual situations.

Technical Reporting

A study of effective ways of presenting information, with emphasis on the use of graphs, drawings, sketches and outlines for various types of oral presentations and written reports.

Sources of Air Pollution

A study of general and industrial processes which are actual or potential contributors to air pollution. Attention is focused on agriculture, transportation, industrial manufacturing and processing and solid waste disposal. Source emission inventories are also studied.

Air Pollution Instrumentation

A study of the application of pneumatic, electronic, mechanical and chemical systems to the measurement of air pollutants. Accuracy of measurements, proper use of instruments and calibration techniques are also considered.

Physics II

Electricity and magnetism, electronic instrumentation and work, energy and power. Principles stressed in lectures are reinforced in laboratory exercises designed to provide practical applications.

Biology

This course is concerned with basic concepts of environmental biology. Such concepts as energy flow, ecological niche, environmental resistance and various factors contributing to the upset of such balance are considered. Also studied are the various measures needed to restore the balance in the ecosystem.

Meteorology

Fundamental meteorological measurements and laws governing the atmospheric variables are presented. An introduction to solar radiation, adiabatic processes and stability, and weather analysis and forecasting. Diffusion from a continuous source is discussed in detail.

Air Pollution Control

Equipment and methods for the control of airborne pollution are studied. Specific topics include process and system control, centrifugal force and gravity methods, filtration, electrostatic precipitation, scrubbing, absorption and combustion.

Air Pollution Sampling and Analysis III

This course is a continuation of source sampling methods. Isokinetic sampling, gas metering, absorption trains, impingers and analytical procedures are studied.

Introduction to Wastewater Technology*

An introduction to the basic concepts of wastewater sources, treatment and effects of treated and untreated wastewater on receiving bodies of water.

Industrial Organizations, Institutions and Government

A study of the roles played by labor and management in development of American industry. Analysis is made of forces affecting labor supply, employment and industrial relations in a democratic system of government.

**Alternate Course:*

Principles of Solid Waste Management

The origin and classification of solid wastes are studied in this course. Also considered are methods of collection, disposal and management of solid waste programs.

Content and Relationships

Functional competence in a broad field such as Air Pollution Technology has at least three components around which the curriculum must be designed.

1. The training should prepare the graduate to be a productive employee in an entry-level job.
2. The broad technical training, together with a reasonable amount of experience, should enable the graduate to advance to positions of increasing responsibility.
3. The foundations provided by the training must be broad enough to enable the graduate to do further study within his field. This further study may consist of reading journals, studying text materials, or enrolling in formal courses.

The curriculum has been designed to meet these requirements.

A two-year technology program has certain unusual requirements that influence the content and organization of the curriculum. Some of these requirements are imposed by the occupational functions that graduates are expected to perform; some requirements result from the emphasis of control agencies and industry on particular areas of air pollution sampling, analysis and control; and others result from the limited time available to produce a competent technician in such a diverse field. This curriculum guide reflects three basic requirements: functional utility, units of instruction in specialized technical subjects, and provision for the teaching of principles of application.

The sequence of courses in a two-year technical curriculum is as important as the content of the courses if the limited time available is to be used most effectively. In general, the subject matter is carefully coordinated in groups of concurrent courses which are arranged to progress smoothly from one group of courses to the next. The student thus gains a deeper understanding of basic principles while broadening his scope of understanding in the many diverse areas of this field. This is in sharp contrast to the arrangement of the usual professional curriculum in which basic and somewhat unrelated courses make up the first part of the study program and specialization is deferred to subsequent terms.

The relationship between laboratory time and class lecture or theoretical study time is of great importance in a technical education curriculum. All of the theory, skills, techniques, and applied principles needed by the technician could be taught in the laboratory without separate and organized theoretical classes. The converse is *not true* — laboratory experience, skills and capability which are the most characteristic attributes of technicians *cannot* be acquired in classrooms *without laboratories*. However, organized and related ideas, concepts, and factual information can be taught in "theory" classes, if the instructor judiciously uses demonstrations and visual aids, employs selected texts and references, and requires regular and systematic outside study by the student. Group teaching usually makes more efficient use of the instructor's time in a "theory" class than in a laboratory and tends to emphasize the development of the student's skills in obtaining knowledge from printed sources. Thus, there must be a special relationship between the amount of the scientific and technical specialty taught in the "theory" classes and that taught in the laboratory. Laboratory work can be started before the student knows much underlying theory. As soon as the underlying theory can be developed and he understands it, it can be incorporated into the laboratory work—which then becomes more significant in teaching the subjects in depth.

Since many basic laboratory skills will have been learned in the first year, and since some basic theory underlying the new material will have been acquired, the laboratory time required to illustrate principle and to teach new material in second-year courses need not be as long as in the first year. Since more technical specialty courses are studied in the second year than in the first, the total laboratory time is greater than that in the first year. Experience has shown that the relative number of semester hours of science or laboratory work in the technical specialty compared to class theory hours should not be reduced materially. Such a reduction usually causes the typical student to lose interest and fail or to abandon the course; or it produces a graduate who is deficient in the absolutely essential laboratory capabilities and is unemployable at the technical level.

In technical curriculums it is mandatory that some specialized technical course work be introduced in the first semester. Deferring this introduction even for one term imposes serious limitations on the effectiveness of the whole curruculum. An early introduction of the technical specialty has several important advantages:

1. It provides motivation. Since the student is enrolled in school to study air pollution technology, it is important to start his training immediately in his specialty. When the first semester consists entirely of general subjects—mathematics, English, social studies—technical students often lose interest.

2. It makes it possible for the student to achieve greater depth of understanding in specialized subjects in the later stages of the two-year program.
3. It enables the student to see immediate application of the principles he studies in the mathematics, chemistry, physics, and communication skills.

Safety and precise laboratory techniques must be an underlying theme throughout the course of study. The technician's work often involves potential dangers that careful procedures combined with an understanding of the equipment and normal safety practice can avoid. In addition to protecting human life, eyes and body members, practice of careful workmanship will also protect the delicate apparatus (such as automated monitoring equipment and precision analytical balances) the technician uses. Safety must be a constant preoccupation, and its practice must be emphasized continually from the beginning of the course.

Discipline in intellectual honesty must be a part of the training of any technician. He must report accurately what he observes. Any modification of the observed data should be fully explained in his record of the work. False reporting, if detected during the training of a technician, should be dealt with severely by the instructor. The original data recorded by an employed technician or inspector may very well become evidence in a court of law and are therefore of great importance.

Throughout the course of study the student is trained in the scientific method of observation and in recording his observations in laboratory reports. He should learn to record his observations in laboratory reports of field notebooks. Laboratory reports are bound, journal-type notebooks which the student is required to maintain throughout his experimental laboratory work. These reports carefully record data, computations, sketches, diagrams, and related information, as well as observations and conclusions of the experiment. Field notebooks are used to record all data taken and observations made while the student is performing field work. The logical method of recording data and information provides a discipline in the technical curriculum consistent with the needs of employed technicians.

From the total program the student should obtain a broad overview of the engineering and scientific aspects of air pollution technology. Field trips to regulatory agencies and industry are helpful in creating interest by showing what air pollution technicians do.

Air Pollution Sampling and Analysis I in the first semester introduces the student to some of the simplified ambient air pollution monitoring methods and analytical techniques. During this same semester, *Atmospheric Pollution* covers the history and scope of the air pollution problem. Also considered are health and economic effects, legal aspects, air quality criteria and standards, and air pollution control administration.

In the second semester, *Air Pollution Sampling and Analysis II* provides a continuation of ambient sampling methods with a consideration of some advanced analytical techniques. This course also introduces some of the elementary concepts of source sampling. The relationship between the specialized air pollution courses and chemistry is so direct that the chemistry courses should be given in the first two semesters. In these courses the student becomes familiar with properties of some common chemical elements and compounds, balancing chemical equations, stoichiometry and the gas laws. He also develops laboratory skills including the preparation of solutions and reagents and the proper use of delicate laboratory equipment.

Mathematics I and *II* present a sequence of selected topics in algebra, trigonometry, analytical geometry, and calculus, which make up the mathematics courses. The inclusion of calculus in *Mathematics II* is not intended to make the student proficient in all aspects of the calculus but rather to help him understand concepts which will permit him to use the calculus as a basic tool in analyzing problems and in communicating with engineers.

Industrial chemistry and processes form an indispensible foundation for the third semester course *Sources of Air Pollution*. Various manufacturing, energy producing and chemical processes are studied to gain an understanding of potential as well as actual sources of air pollution. The preparation, use and interpretation of source emission inventories as a tool in establishing and evaluating control programs are studied in detail.

Air Pollution Instrumentation is designed to acquaint the student with some of the basic measuring instruments and how they function. He will learn to make simple repairs and adjustments and perform general maintenance as well as calibrate instruments. Consideration is given to the ways in which various types of systems such as electronic, pneumatic, mechanical and chemical can be used together to perform certain functions. Some of the major types of instrumental analysis techniques are studied. Appendix C presents some sample instructional materials derived from this course.

In the fourth semester, *Air Pollution Sampling and Analysis III* provides a capstone for the field/laboratory sequence with a consideration of advanced source sampling topics. *Meteorology* includes the study of air pollution climatology, diffusion of air pollutants from point sources, weather forecasting, and movement of local, regional and planetary air masses.

Air Pollution Control examines different types of air pollution control equipment, their applications, limitations and comparative cost data. Laboratory time is provided with this course to take field trips in order to see installations of the various equipment types studied.

The student must become aware of the interrelations between air and water pollution and the disposal of solid waste. Often, the solution to an air pollution problem can create a water pollution condition, and vice versa. *Introduction to Wastewater Technology* is designed to supply an understanding of some of the basic problems in this area. Sources, quantities and composition of wastewater are studied, as are some of the methods of treatment and disposal. As an alternate to the wastewater course, the student may study the *Principles of Solid Waste Management*. This course consists of an examination of the solid waste problems; including sources, types and quantities and methods of collection. Major types of solid waste disposal such as incineration, composting and sanitary landfilling are compared in terms of the advantages and disadvantages of each.

As important as knowledge about the relationships between air, water and solid wastes, is the relationship of man with his total environment. The *Biology* course is a study of some of these ties. Ecology, energy flow and biogeochemical cycles in ecosystems are examples of topics studied in this course.

Communication Skills emphasizes the mechanics of reading, writing, listening, speaking, and reporting early in the curriculum (first semester). In the second semester the student reinforces his skills in *Technical Reporting*. Instructors in technical courses should set increasingly high standards of clarity, conciseness, and neatness for student work in reporting. Freedom to report on technical subjects of their own choice may add reality and extra motivation for technology students. In the final phases of the two-year program the standards of reporting should approximate those required by employers. At the same time instructors should encourage the students to develop individual style and initiative by allowing him as much freedom as possible in reporting, consistent with established school standards.

Not all reports should be of a type which require a disproportionately large number of hours for preparation. The judicious use of informal reporting as well as formal reporting allows for training in both forms with the realism required in employment, and adjusts the time required of students in writing formal reports to a reasonable proportion of their time.

The course outlines included in this guide are concise and comprehensive, intended as guides rather than as specific plans of instruction to be covered in an inflexible order. They represent a judgment on the relative importance of each instructional unit, especially where time estimates are shown for the divisions within each course. The instructor is expected to supplement the principles outlined in these courses with practical applications whenever relevant. Field trips add greatly to the effectiveness of the instruction if they are carefully planned so that students understand the work they observe, and relate it to the subject material they are studying at the time of the trip. Operational safety should be emphasized in field trip studies, and liability insurance covering the students on such trips should be provided by the institution.

Outside study is a significant part of the student's total program. In this curriculum, *2 hours of outside study time are suggested for each hour of scheduled class time*. For example, a typical weekly work schedule for a student in the first semester of this curriculum would be: class attendance, 14 hours; laboratory, 9 hours; outside study, 28 hours—a total of 51 hours per week. This is a full schedule, but not excessive for this type of program.

Whenever possible, summer employment in the air pollution field should be arranged for the student between the second and the third semester. Often local control agencies and industry will cooperate with such a program because they need relief workers during the vacation season. Some institutions may organize employment experience as a part of a cooperative plan. plan.

COOPERATIVE EDUCATION PLAN

This technology is adaptable to a cooperative arrangement: a plan which offers important advantages to students, to the school, and to employers of technicians. A cooperative education program is a plan for a student to learn through coordinated study and employment experience. The student alternates periods of attendance at the institution where he is receiving his technical education with periods of employment in public control agencies or industry. The employment constitutes an essential element in his education. The student's employment should be related as closely as possible to some phase of the field of study in which he is engaged.

When a student tests his knowledge of theory in a work situation, study becomes more meaningful. The co-op student learns not only the essentials of his technology but also the importances of reliability, cooperation, and judgment as an employed worker in his chosen field.

The co-op student's career choice is stimulated and shaped by his work experiences. If he finds satisfaction in his work, he returns to the classroom stimulated to learn as much as possible about his future career. If he finds through his work experience that he is not fitted to a specific area of work, he may decide to change his major field of study when he returns to the college. This decision may prevent him from wasting his time and money on a misguided choice of study.

A class of students in cooperative technical programs usually spends the first semester or the first two quarters in school; then it is divided so that half the students have a semester or quarter of employment experience while the other half contines to study. During the next semester or quarter, the half who have worked return to their formal studies at school while the other half are employed. They usually alternate again so that each student has two semesters or at least two quarters of work experience in his program. The student's technical program is lengthened beyond the curriculum outlined in this document by an amount of time equal to the total length of the employment experience.

Specific employment is obtained, as circumstances permit, by the educational institution with the cooperation of the student. The institution regards the work-experience program as an integral part of the technician program as a whole. It is not regarded primarily as an opportunity for earning, although each student while working is paid at the prevailing wage scale for the job he holds. Work reports by both the student and the employer are submitted to the school work program coordinator.

The cooperative work-experience program is an opportunity for the student to gain directly related experience which makes him more valuable as an employee. As a result of their work experience in particular establishments, many students have been offered permanent positions upon completion of their schooling. Cooperating establishments agree, however, not to make offers of employment which become effective before the technician completes his program.

Cooperative programs provide opportunities for the educational institution to maintain close contact with employers in their various programs. This contact becomes a two-way channel of communication which helps the educational institution to keep its knowledge of specific employer needs in each technical field up to date, and at the same time keeps employers acquainted with and involved in the program of the institution.

SUGGESTED CONTINUING STUDY

A two-year curriculum must concentrate on the primary needs of science, mathematics, and the related knowledge and skills in the technical specialty necessary to preparing the student for employment upon graduation.

Obviously, a two-year program cannot cover in depth all of the subjects pertinent to the technology; certain important, related subjects may only be touched upon. In addition, the graduate may obtain work in an area of the industry so new that adequate coverage in the training program has not yet been developed.

For these reasons, some form of continuation of study for graduates of technology programs is desirable. The student can keep abreast of the technical developments in his special field by reading the current literature related to the technology, by attending meetings of scientific and technical societies, and by study on his job. Such study tends to build on the organized, technological base provided by the curriculum he studied. Formal continuation of supplementary courses provides the most efficient and practical means for the graduate technician to add important knowledge and skill to broaden the base of his initial education. Formally organized courses have the advantages of systematic arrangement of subject matter, disciplined and competent teaching, and class discussion. They may be scheduled for evening or Saturday hours outside of the graduate technician's working day.

Rapid advances in the basic science and engineering principles of air pollution technology will require a continual updating of knowledge in the employed graduate technician.

Some continued study suggested for the graduate might include the following fields or subjects:

Advanced Air Quality Studies
Advanced Chemical Analysis
Chemical Process Control
Conservation
Data Processing
Economics
Engineering Drawing
Instrumental Analysis
Meteorology
Microbiology
Noise Measurement and Control
Physics and Mathematics
Solid Wastes Management
Supervision & Management
Wastewater Technology

COURSE OUTLINES

The courses outlined suggest the content which might be taught in the curriculum. These materials provide a practical and attainable coverage of the field and have been reviewed by experienced instructors in successful educational programs for air pollution technicians and by experts representing employers of such technicians.

Successful programs can be conducted as semester, quarter or trimester systems. The two-semester a year system illustrated in this document can be changed into three quarters or terms if advisable to meet community needs. Course content can be distributed over six quarters, since the total time in six quarters is approximately the same as in four semesters.

The materials will very likely be modified to fill local needs and to take advantage of special interests and capabilities of the teaching staff; but the implied level, quality, and completeness of the program should not be compromised.

No examinations have been scheduled in the outlines. It is clearly intended that time be available for examinations. Therefore, a 17-week semester is assumed, and the outlines are designed to cover a full 16 weeks. The primary objectives of examinations would be to evaluate the student's knowledge and cause him to make a periodic, comprehensive review of the material presented in the course. The results of examinations may also point out weaknesses in teaching techniques or subject matter covered.

At the end of each course there is a list of text and reference materials. Each should be analyzed for its content and pertinency, and new and more suitable ones should be used if they are available. The information needed to cover a particular course in technician curriculums, particularly the technical specialty courses, is almost never available in one textbook; hence the multiple listing of references. They should usually be considerably augmented by current materials from manufacturers, trade journals, technical societies, and suppliers of equipment and materials in the special field of applied science being studied.

Suggested visual aids are listed for many courses. Each should be used when pertinent and when its use will teach more efficiently than any other method. *Excessive showing of films at the expense of well-prepared lectures and demonstrations is to be avoided.* The suggested outside study periods may well be used instead of class lecture time for the showing of some films. All visual aids should be examined by the instructor before they are shown. Those listed after courses usually show name and address of supplier, size in mm., minutes required for showing, and whether they are sound or silent. This provides the necessary information for selection to fit projection equipment.

The experienced instructor is expected to make liberal use of charts, slides, models, samples, drawings, and specimens which illustrate special technical aspects of the subject. He usually accumulates them from the experience in previous laboratory or lecture preparations and updates regularly when new developments require it. They are too specific for any attempt to be made to list them in this guide.

The laboratory sessions suggested in the outline and in the course descriptions are not necessarily intended to be a single session but rather to be scheduled in reasonable and effective increments. For example, a 6-hour laboratory total per week for a course might be scheduled as two 3-hour sessions, or any other divisions of laboratory time that seem appropriate.

It will be noted from the Curriculum Outline that several alternative courses are included in the curriculum. These courses, outside the air pollution specialty area but related to the broad environmental technology field, are intended as options for the institution and the student. Thus, depending on the interests of, and resources available to the institution, it might be desirable to offer either or both of the optional courses. The decision as to whether to offer these courses would depend on several factors including the background and expertise of the faculty, local industrial installations, student interests, etc. Offering the optional courses would provide greater flexibility to the program and allow the student to choose among the options those most closely allied with his employment goals.

TECHNICAL COURSES

ATMOSPHERIC POLLUTION

Hours Per Week

Class, 3

Description

Air pollution is considered in several different aspects as an urgent problem confronting a largely urbanized technologically-based society. Starting with several working definitions of air pollution, the student examines types of pollutants, their significant chemical and physical properties and their most common sources. A historical review of air pollution precedes a consideration of the effects of common air pollutants on man and animals, the atmosphere, vegetation and various kinds of materials. A brief overview of meterorology is included to indicate the importance of this science to the control of air pollution. The student is introduced to some of the major considerations of ambient and source sampling techniques. Major types of control equipment are then considered, followed by a study of the importance of air quality criteria and standards, and the major elements of an air pollution control program.

Major Divisions

		Class hours
I.	The Air Pollution Problem	3
II.	Historical Review of Air Pollution	2
III.	Air Pollutants and Their Effects	8
IV.	Sources & Levels of Air Pollution	6
V.	The Role of Meteorology in Air Pollution	3
VI.	Air Pollution Sampling and Analysis	4
VII.	Prevention and Control of Air Pollution	4
VIII.	Air Quality Criteria and Standards	9
IX.	Air Pollution Control Programs	9
		48

I. The Air Pollution Problem

A. Working definitions of air pollution
  1. Recognition of the problem
  2. Public health aspects
  3. Determining safe levels of emissions
  4. Relationship to air quality standards
B. Characteristics of pollutants
  1. Man-made and natural pollution
  2. Airborne particulates
    a. Smoke
    b. Fog
    c. Haze
    d. Dust
  3. Gases and vapors
  4. Radioactive fallout
C. Concentrations of pollutants
  1. Common methods for expressing concentrations
    a. Smoke density
    b. Particulates, suspended
    c. Dustfall
    d. Gases
    e. Radioactive materials
    f. Unit conversions
  2. Standard conditions
    a. Pressure
    b. Temperature
    c. Moisture content
  3. Literature sources of typical air pollution levels
    a. Environmental Protection Agency publications
    b. Other bibliographic references

II. Historical Review of Air Pollution

A. Smoke (13th Century)
B. Sulfur dioxide (1600 A.D.)
C. Industrial revolution (1760 A.D.)
  1. Chemical process industries
  2. Metallurgical processes
D. Smog (1943)
E. Major air pollution crises
  1. Meuse Valley, 1930
  2. Donora, Pennsylvania, 1948
  3. London, 1952
  4. New York, 1963, 1966
  5. Similarities and dissimilarities
    a. Topography
    b. Morbidity and mortality
    c. Meteorology
    d. Emission sources

III. Air Pollutants and Their Effects

A. Effects on the atmosphere
  1. Visibility
    a. Particulates
    b. Nitrogen dioxide
  2. Climate
    a. Carbon dioxide
    b. Particulates
    c. Vapor trails

B. Air pollution and vegetation
  1. Sulfur dioxide
    a. Absorption by plants
    b. Reducing property of SO_2
    c. Sulfate toxicity
    d. Local injury
    e. Plant species susceptible to SO_2 injury
  2. Fluorine compounds
    a. Absorption by plants
    b. Fluoride lesions on plants
    c. Plant species susceptible to fluoride injury
  3. Smog
    a. Reducing (London type)
      (1) SO_2
      (2) Particulates
    b. Oxidizing (L. A. type)
      (1) Ozone
      (2) Acid aerosols
      (3) Hydrocarbons
      (4) Oxides of nitrogen
      (5) Synergistic effects
      (6) Plant species susceptible to smog damage
  4. Miscellaneous pollutants affecting vegetation
    a. Chlorine
    b. Hydrogen chloride
    c. Ammonia
    d. Hydrogen sulfide
  5. Economic aspects
    a. Decrease in production area
    b. Decrease in yield

C. Effects on materials
  1. General material damage
    a. Damage to textiles & clothing
    b. Damage to wallpapers and curtains
    c. Maintenance and paint work
    d. Corrosion of metals
    e. Erosion of statuary and buildings
    f. Damage to rubber
    g. Leather and paper
  2. Economic aspects
    a. Maintenance
    b. Shorter useful life
    c. Special protection
    d. Over design

D. Effects on animals
  1. Morbidity/mortality associated with air pollution episodes
  2. Domestic pets
  3. Poultry
  4. Large farm animals
  5. Endangered species
  6. Air pollutants affecting animal health
    a. Oxidants
    b. Fluorides
  7. Economic effects

E. Effects on human health
  1. Morbidity/mortality associated with air pollution episodes
    a. Meuse Valley, Belgium (1930)
    b. Donora, Pennsylvania (1948)
    c. London, England (1952)
    d. Los Angeles, California
    e. Poza Rica, Mexico (1950)
    f. New York
  2. Sulfur dioxide and sulfur trioxide
  3. Ozone
  4. Particulates
  5. Pollutants resulting in systematic effects
    a. Carbon monoxide
    b. Beryllium
    c. Fluorides
    d. Aeroallergens
    e. Carcinogens
    f. Insecticides
  6. Miscellaneous effects

IV. Sources and Levels of Air Pollution

A. Transportation
  1. Contribution
  2. Major pollutants
    a. Carbon monoxide
    b. Hydrocarbons
    c. Nitrogen oxides
  3. Specific sources from internal combustion engines
    a. Exhaust
    b. Evaporation
    c. Crankcase blow-by

B. Fuel combustion in stationary sources
  1. Contribution to overall air pollution
  2. Major pollutants
    a. Sulfur oxides
    b. Nitrogen oxides
    c. Particulates

3. Source types
   a. Gas-burning
   b. Oil-burning
   c. Solid fuel burning

C. Industrial processes
   1. Contribution to overall air pollution
   2. Major pollutants
      a. Carbon monoxide
      b. Particulates
      c. Sulfur oxides
      d. Hydrocarbons
   3. Process types
      a. Petroleum refining
      b. Nonmetallic mineral products
      c. Metallurgical processes
         (1) Ferrous
         (2) Nonferrous
      d. Inorganic chemical processes
      e. Pulp and paper industry
      f. Food and feed industry

D. Incineration of solid wastes
   1. Contribution to overall air pollution
   2. Major pollutants
      a. Carbon monoxide
      b. Hydrocarbons
      c. Particulates

E. Miscellaneous sources
   1. Contribution to overall air pollution
   2. Major pollutants
      a. Oxides of carbon, sulfur and nitrogen
      b. Particulates
      c. Hydrocarbons
   3. Specific sources
      a. Forest fires
      b. Agricultural burning
      c. Coal waste fires
      d. Pollen producing vegetation

V. The Role of Meterology in Air Pollution

A. Dilution of pollutants
   1. General winds
      a. Speed
      b. Direction
      c. Wind roses
   2. Local winds
      a. Sea-breezes
      b. Effects due to topography
   3. Turbulence
      a. Mechanical
      b. Thermal
   4. Lapse rates
      a. Adiabatic
      b. Unstable
      c. Stable
      d. Inversions

B. Natural removal of pollutants
   1. Gravitational settling
   2. Precipitation
      a. Removal of particulate matter
      b. Removal of gaseous contaminants
   3. Surface impaction

VI. Air Pollution Sampling and Analysis

A. Reasons for sampling
   1. Meeting occupational health standards
   2. Determining ambient concentrations of pollutants
   3. Locating the origin of pollutants
   4. Determining the efficiency of control equipment

B. Approaches to sampling
   1. Sampling emissions from individual stacks
   2. Community air sampling

C. Sampling particulate matter
   1. Visual methods
      a. Ringelmann charts
      b. Photometric devices
      c. Nephelometer
   2. Settling devises
      a. Chambers
      b. Petri dishes
      c. Microscope slides
      d. Fallout containers
   3. Filtration devices
      a. Sampling trains
      b. Membrane filters
      c. Hi-vol samplers
      d. Tape sampler

D. Sampling gaseous pollutants
   1. Static samplers
      a. Lead dioxide candles
      b. Sulfation plate
      c. Deterioration of rubber
      d. Limed filter paper
      e. Fabric panels
   2. Sampling trains
   3. Automatic sampling devices
   4. Vegetation analysis
   5. Grab sampling

VII. Prevention and Control of Air Pollution

A. Control by site selection and zoning
   1. Planning and land use
   2. Zoning ordinances
   3. Large air pollution zoning jurisdictions
   4. Inter-state compacts
   5. International agreements
   6. Plant location

- B. Control by process change or equipment
  - 1. Process changes
    - a. Substitution of raw materials or fuels
    - b. Modification of equipment
    - c. Improvement of operating procedures
  - 2. Application of control equipment
    - a. Gravity settling chambers
    - b. Inertial separators
    - c. Cyclonic separators
    - d. Filters
    - e. Electrostatic precipitators
    - f. Scrubbers
    - g. Incineration
- C. Meteorological control
  - 1. Use of tall stacks
  - 2. Use of optimum dispersion conditions

VIII. Air Quality Criteria and Standards

- A. Air quality criteria
  - 1. Criteria for biological effects
  - 2. Criteria for physical effects
- B. Air quality standards
  - 1. Distinction between standards and threshold limit values
  - 2. Setting standards
    - a. Using air quality criteria
    - b. Using another community's standards
    - c. Using earlier levels
    - d. Establishing air quality regions
- C. Emission standards
  - 1. Setting emission standards
    - a. Using air quality standards
    - b. Using process, fuel, and equipment information
  - 2. Typical emission standards
    - a. Objective standards
    - b. Subjective standards
- D. Miscellaneous standards
  - 1. Buffer zones
  - 2. Stack heights
  - 3. Equipment
  - 4. Fuel
  - 5. Tests

IX. Air Pollution Control Programs

- A. Objectives
  - 1. Preserve the health and welfare of man
  - 2. Protect plant and animal life
  - 3. Prevent damage to physical property
  - 4. Provide visibility for safe transportation
  - 5. Ensure an esthetically acceptable and enjoyable environment
- B. Governmental air pollution control programs
  - 1. Local governmental programs
  - 2. State governmental programs
  - 3. Interstate governmental programs
  - 4. Federal governmental programs
- C. A typical air pollution control program
  - 1. Defining air pollution problems
    - a. Emission inventories
    - b. Air quality measurements
    - c. Monitoring air pollution effects
    - d. Complaints
    - e. Visual detection
    - f. Source sampling
  - 2. Correcting problems
    - a. Preparation of air quality standards
    - b. Preparation of emission control regulations
    - c. Enforcement of laws and regulations
    - d. Air pollution alert system

Texts and References

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE. *Air Conservation.*
CORMAN. *Air Pollution Primer.*
LEINWAND. *Air and Water Pollution.*
STERN. *Air Pollution.* Vol. 1, 2 and 3.
TRESHOW. *Whatever Happened to Fresh Air?*
WILLIAMS AND EDMISTEN. *An Air Resource Management Plan for the Nashville Metropolitan Area.*
WORLD HEALTH ORGANIZATION. *Air Pollution.*

Visual Aids

U. S. Public Health Service, Audiovisual Facility, Atlanta, Ga. 30333.

Effects of Air Pollution, MIS-678, 16 mm., 5 min., color, sound.

Pall Over our Cities, MIS-985, 16 mm., 15 min., b/w, sound.

The Human Body: Respiratory System, MA-31, 16 mm., 13 min., color, sound.

The Poisoned Air, M-1418-X, 16 mm., 50 min., color, sound.

AIR POLLUTION SAMPLING AND ANALYSIS I

Hours Per Week

Class, 2; Laboratory, 6

Description

In this laboratory-based course, the major types of ambient air sampling and analysis techniques are considered. Class periods are used primarily to introduce and discuss various aspects of ambient monitoring and to provide post-laboratory calculation and discussion sessions. The major emphasis of the course is directed toward the laboratory periods, in which the students get first-hand practical experience with survey sampling methods and analytical techniques.

It will be noted that the specific topics pertaining to ambient particulate and gaseous sampling methods receive major allotments of the total time available. This is done so that certain types of monitoring tests such as atmospheric sulfation levels, which require extensive reagent, test instrument makeup and analysis time are adequately provided for. It is also desirable, where time permits, to perform the same analysis on several sets of samples to gain additional proficiency with the method.

Major Divisions

	Hours	
	Class	*Laboratory*
I. Principles of Ambient Sampling	2	3
II. Methodology of Ambient Sampling	3	6
III. Site Selection and Preparation	1	6
IV. Data Collection and Reduction	1	3
V. Sources of Comparative Data	1	3
VI. Ambient Particulate Sampling Methods	12	63
VII. Ambient Gaseous Sampling Methods	12	12
Total	32	96

I. Principles of Ambient Sampling

- A. Units of instruction
  - 1. Reasons for ambient sampling
    - a. Establish hazardous levels of pollution
    - b. Study the effects of control measures
    - c. Study the effects of a specific process or source on ambient pollutant concentrations
  - 2. Quantitative determination of atmospheric pollutants
    - a. Collection of samples
    - b. Refinement of collected samples
    - c. Analysis of samples
    - d. Calculation and presentation of results
  - 3. Determination of sample size
    - a. Minimum concentration of pollutant
    - b. Sensitivity of analytical technique
    - c. Trial and error procedure
  - 4. Determination of sampling rate
    - a. Collection device
    - b. Optimum flow rate
  - 5. Determination of sampling time
    - a. Average concentrations
    - b. Pollutant concentration expected
    - c. Optimum sampling rate
      - (1) Sampling method
      - (2) Equipment used
    - d. Analytical procedure
  - 6. Miscellaneous considerations
    - a. Changes in pollutants due to collection method
    - b. Changes in sample due to storage
    - c. Use of automatic samplers
    - d. Recommended units for results
  - 7. Physical properties of aerosols
    - a. Settling velocity of particles
    - b. Brownian movement
    - c. Agglomeration
- B. Laboratory projects
  - 1. For the high volume filter sampler and a hypothetical concentration of particulates, consider the following:
    - a. Expected efficiency of the high volume sampler
    - b. Weight of sample needed for analysis
    - c. Minimum sample volume
    - d. Optimum sampling rate
    - e. Sampling time required
    - f. Calculation and presentation of results
  - 2. Research the literature for the recommended units and expected ranges of data for each of the following:
    - a. Particle fallout
    - b. Airborne particulate concentrations
    - c. Gaseous pollutant concentrations
    - d. Particulate counts
    - e. Temperature
    - f. Time
    - g. Pressure
    - h. Linear velocity
    - i. Sampling rates
  - 3. Study the following instruments and practice using them to determine the physical properties of the ambient air.

- a. Barometer
- b. Fahrenheit and celsius thermometers
- c. Sling psychrometer
- d. Hair hygrometer

II. Methodology of Ambient Sampling

- A. Units of instruction
  - 1. Sampling aerosol pollutants
    - a. Filtration
      - (1) Principles of filtration
      - (2) Filter types
        - (a) Fiber filters
        - (b) Granular filters
        - (c) Membrane or molecular filters
      - (3) Particle size – collection efficiency relationship
    - b. Impingement
      - (1) Principles of impingement
      - (2) Collection devices
        - (a) Wet collectors
        - (b) Impactors
      - (3) Particle size-collection efficiency relationship
    - c. Dustfall collection
      - (1) Principles of collecting dustfall
      - (2) Dustfall devices
      - (3) Particle size-collection efficiency relationship
    - d. Precipitation
      - (1) Principles of precipitation
      - (2) Collection devices
        - (a) Electrostatic precipitators
        - (b) Thermal precipitators
      - (3) Particle size-collection efficiency relationship
    - e. Dust counters
      - (1) Light scattering methods
      - (2) Potentiometric methods
  - 2. Sampling gaseous pollutants
    - a. Grab sampling
      - (1) Principles of grab sampling
      - (2) Grab sampling devices
        - (a) Evacuated bottles and flasks
        - (b) Plastic envelopes and balloons
        - (c) Cylinders
        - (d) Chemically impregnated adsorbents or papers
      - (3) Limitations
    - b. Condensation or freezeout techniques
      - (1) Principles of freezeout methods
      - (2) Freezeout equipment and materials
        - (a) Coolants
        - (b) Wide-mouthed Dewar Vessels
        - (c) Collectors (traps)
      - (3) Limitations
    - c. Absorption techniques
      - (1) Principles of adsorption
      - (2) Adsorbent properties
        - (a) Granular
        - (b) Low resistance to flow
        - (c) High effective adsorption capacity
        - (d) Inert
        - (e) Resists breakage
      - (3) Removal of adsorbate for analysis
      - (4) Limitations
    - d. Absorption techniques
      - (1) Principles of absorption
      - (2) Absorption devices
        - (a) Fritted glass scrubbers
        - (b) Impingers
        - (c) Packed columns
        - (d) Countercurrent scrubbers
        - (e) Atomizing scrubbers
      - (3) Limitations

- B. Laboratory projects

  - 1. Examine each of the following devices carefully. Pay particular attention to construction, maintenance, operation and auxiliary equipment requirements.
    - a. High volume filter sampler
    - b. Membrane filter and holder
    - c. Cascade impactor
    - d. Greenburg-Smith impinger
    - e. Electrostatic precipitator sampler
    - f. Thermal precipitator sampler

  - 2. Sample the laboratory air using each of the following. Analyze the samples microscopically where necessary and plot a size distribution curve for each sample.
    - a. Dust counter
    - b. Cascade impactor
    - c. Electrostatic precipitator sampler

  - 3. Discuss equipment requirements and sampling methods for each of the following:
    - a. Conducting a community survey
    - b. Establishing the location of a source of pollution
    - c. Measuring pollutant concentrations for occupational health

III. Site Selection and Preparation

- A. Units of instruction
  - 1. Preparations for air pollution surveys
    - a. Air sampling networks (CAMP, NASN)
    - b. Meteorological observation networks
    - c. Aerometric station networks
    - d. Air sampling stations
      - (1) Type I
        - (a) Dustfall buckets
        - (b) Lead dioxide candles or plates
      - (2) Type II
        - (a) Dustfall buckets
        - (b) Lead dioxide candles or plates
        - (c) High volume filter sampler
        - (d) Wind speed indicator
      - (3) Type III
        - (a) Dustfall buckets
        - (b) Lead dioxide candles or plates
        - (c) Wind speed and direction
        - (d) Miscellaneous sampling equipment for sampling SO_x, NO_x, oxidants, and CO
  - 2. Criteria for selecting sampling sites
    - a. Position of sites in relation to buildings
    - b. Position of sites in relation to trees
    - c. Power availability
    - d. Air sampling station supports
    - e. Protection of stations from vandalism
- B. Laboratory projects
  - 1. Make a field trip to an air sampling station. Observe the types of supports used, the types of sampling devices used and meteorological equipment present. What methods are used to discourage vandalism?
  - 2. Study maps of several community or regional air sampling networks. Investigate the reasoning behind the selection of the sampling sites. Examine the results of the surveys.

IV. Data Collection and Reduction

- A. Units of instruction
  - 1. Collection of data
    - a. Tabular forms
    - b. Graphical (chart) readouts
    - c. Digital readouts
  - 2. Data reduction
    - a. Graphical techniques
      - (1) Frequency tables
      - (2) Frequency polygons
      - (3) Histograms
      - (4) Cumulative frequency distribution
    - b. Particle size data
      - (1) Frequency distribution curves
      - (2) Cumulative distribution curves
    - c. Data analysis
      - (1) Measures of central tendency
        - (a) Mean
        - (b) Median
        - (c) Mode
      - (2) Measure of variability
        - (a) Range
        - (b) Standard deviation
- B. Laboratory projects
  - 1. Using a set of data representing pollutant levels for a given hour of the day for several days, construct the following:
    - a. A frequency table
    - b. A frequency polygon
    - c. A histogram
    - d. A cumulative frequency distribution
  - 2. Plot a frequency distribution curve and a cumulative distribution curve for a set of particle-size measurements.
  - 3. For the set of data above, calculate the following:
    - a. The median
    - b. Mean, arithmetic
    - c. Mean, geometric
    - d. The range
    - e. The standard deviation

V. Sources of Comparative Data

- A. Units of instruction
  - 1. Survey reports
    - a. Local surveys
    - b. Regional surveys
    - c. Continuous Air Monitoring Program
    - d. National Air Sampling Network
  - 2. Publications
    - a. Professional journals
    - b. Proceedings
    - c. American Society for Testing Materials
    - d. Los Angeles Air Pollution Control District
    - e. Environmental Protection Agency publications
- B. Laboratory projects
  - 1. Locate one or more sources of air pollution data in your library.

2. Estimate pollution levels in your community using available data on other communities.

VI. Ambient Particulate Sampling Methods

A. Units of instruction
1. Dustfall containers
a. Container design
b. Container support and bird rings
c. Sampling procedures
(1) Exposure time
(2) Use of water as collecting medium
(3) Algicides and antifreeze
(4) Locating stations
d. Analysis
(1) Screening
(2) Soluble solids
(3) Insoluble solids
(4) Presentation of results
e. Standards for dustfall sampling
f. Importance of dustfall sampling
(1) Indicating major sources of pollution
(2) Indicating long term changes in pollutant levels
(3) Indicating the effectiveness of control programs
g. Advantages
(1) Minimum equipment costs
(2) Simplicity of collection
(3) Simplicity of analysis
h. Disadvantages
(1) Collection area is small
(2) Sampling does not allow detection of peaks
2. High volume filter sampler
a. Equipment description
(1) Filter adaptor
(2) Fiber filters
(3) Blower
(4) Shelter designs
b. High volume sampler calibration
(1) Orifice calibration
(2) Visifloat calibration
(3) Plotting calibration curves
c. High volume sampler operation
(1) Sampling period
(2) Sampling rate
(3) Electrical requirements
(4) Initial and final flow rate measurements
(5) Maintenance
d. Analyses
(1) Total weight of suspended particulates
(2) Weight of solvent soluble fractions
(3) Radioactivity
e. Importance of high volume samples
(1) Determining day-to-day pollutant levels
(2) Assaying effectiveness of control programs
f. Disadvantages
(1) Cost of sampler and shelter
(2) Filter cost
(3) Electricity requirements
(4) Maintenance and replacement costs
3. Tape samplers
a. Equipment description
(1) Vacuum pump
(2) Sampling nozzle
(3) Automatic timer
(4) Sampling tape
(5) Transmissometer
b. Sampler calibration
c. Sampler operation
(1) Sampling period
(2) Rate of flow
d. Analysis
e. Advantages
(1) Variation of sampling periods
(2) Large number of readings per day
(3) Automatic
(4) Indicates soiling capabilities of particles
f. Disadvantages
(1) High initial cost
(2) Need for electricity
(3) Maintenance costs
4. Miscellaneous particulate samplers
a. Impingers
b. Cascade impactors
c. Precipitators
d. Membrane filters
e. Anderson Samplers
f. Sticky tape samplers

B. Laboratory projects
1. Conduct a community air pollution survey. Continue the survey for at least two months.
a. Set up sampling stations in the community
b. Prepare the following for the survey:
(1) Dustfall buckets
(2) Lead dioxide candles
(3) Sulfation plates
(4) Optional apparatus
(a) Corrosion plates
(b) Rubber strips

(c) Silver coated plates
(d) Fabric panels
c. Place the sampling apparatus in the community sampling stations
d. Collect the sampling apparatus after an appropriate length of time and analyze the samples
2. Calibrate a high volume sampler and an automatic tape sampler.
3. Place the high volume sampler and tape sampler at pre-selected sites in the community and operate for 24 hours.
4. Analyze the samples taken by the high volume sampler and the automatic tape sampler. Compare the results.
5. Study each of the following devices and demonstrate their use:
   a. Rotorod sampler
   b. Cascade impactor
   c. Thermal and electrostatic precipitators
6. Collect a sample of the particles in the laboratory air on a membrane filter. Also collect a sample of the particles in the outside air. Compare the samples under the microscope.

VII. Ambient Gaseous Sampling Methods

A. Units of Instruction
1. Sampling by adsorption
   a. Typical adsorbents
      (1) Carbon
      (2) Silica gel
      (3) Activated alumina
      (4) Molecular sieve
   b. Contacting methods
   c. Regeneration of adsorbent
2. Sampling by absorption
   a. Selection of absorbing solutions
   b. Gas-liquid contactors
3. Condensation techniques for sampling gases
   a. Sampling trains
   b. Freezing solutions
      (1) Ice salt
      (2) Dry ice-acetone
      (3) Liquid nitrogen
   c. Estimating sampling rates
   d. Analysis
4. Grab sampling
   a. Evacuated containers
   b. Purging
   c. Displacement of a liquid
   d. Inflation of a plastic bag
   e. Syringes
5. Analyses for specific pollutants
   a. Sulfur dioxide
      (1) Colorimetric SO_2 detection
      (2) Time-discoloration measurements
      (3) Lead dioxide candles
      (4) Sulfation plates
      (5) Electro-chemical methods
   b. Hydrogen sulfide
      (1) Lead acetate test paper
      (2) Silver cyanide detector
      (3) A.I.S.I Hydrogen sulfide sampler
      (4) Cadmium hydroxide—methylene blue method
   c. Oxides of nitrogen
      (1) Sampling train configuration
      (2) Preparation of Saltzman reagent
      (3) Preparation of potassium permanganate
      (4) Spectrophotometric analysis
   d. Oxidants
      (1) Neutral-buffered potassium iodide method
      (2) Rubber cracking method
   e. Miscellaneous techniques
      (1) Hydrocarbon analyzers
      (2) Halogen detectors
      (3) Fabric panels
      (4) Corrosion plates
      (5) Silver coated plates
   f. Carbon monoxide and carbon dioxide

B. Laboratory projects
1. Assemble a sampling train for sampling by the condensation (freeze-out) method. Discuss the problems associated with this method and discuss methods for analyzing the samples.
2. Operate an automatic sampler with special tape for sampling hydrogen sulfide.
3. Set up a 24 hour sequential sampler and sample for some of the following:
   a. Oxides of nitrogen
   b. Oxidants
   c. Oxides of sulfur
   d. Organic compounds
   e. Inorganic gases

Texts and References

AMERICAN SOCIETY FOR TESTING MATERIALS. *Index to ASTM Standards.*

SHEEHY AND OTHERS. *Handbook of Air Pollution.*

STERN. *Air Pollution,* Vol. 2.

U.S. PUBLIC HEALTH SERVICE. *Air Pollution Measurements of the National Air Sampling Network.*

WORLD HEALTH ORGANIZATION. *Air Pollution*
Analytical Chemistry
Archives of Industrial Health
Journal of the Air Pollution Control Association.
Journal of Laboratory and Clinical Medicine.
Journal of Scientific Instrumentation.

Visual Aids

U. S. Environmental Protection Agency. Technical Audio-Visual Branch. Research Triangle Park, N.C. 27711.
Estimation of SO_2 by Lead Candle Methods. MA-42, 16 mm., 24 min., color, sound.

Tape Sampler Calculations, MA-43, TV Tape Kinescope, 20 min.

Hi-Vol Calibration, MA-33, 16 mm., 15 min., color, sound.

Measurement of Particulate Pollutants, SA-35, 35 mm., 14 min., sound (companion audio tape TSA 37).

AIR POLLUTION SAMPLING AND ANALYSIS II

Hours Per Week

Class, 2; Laboratory, 6

Description

The second course in the sampling and analysis series serves as a "bridge" between two different kinds of sampling. Beginning with a review of some of the ambient sampling methods and a consideration of some advanced analyses, the course then moves into the area of source sampling. The gas laws and psychrometry are jointly studied. Following this is an introduction to some of the problems involved in source sampling, including methods of determining gas velocities and flow rates, selection of sampling equipment, the location of suitable sampling sites and preparations necessary to conduct a source test. Data collection procedures are considered as well as calculation and presentation of results. Laboratory exercises begin with a continuation of ambient sampling and analysis techniques and progress through various stages of source sampling to conducting an actual particulate source sampling test.

Major Divisions

	Hours	
	Class	*Laboratory*
I. Review of Ambient Sampling Principles	2	6
II. Sampling Specific Ambient Air Pollutants	2	6
III. Introduction to Source Sampling	4	3
IV. The Ideal Gas Laws and Psychrometry	4	3
V. The Measurement of Gas Velocities and Flow Rates	5	9
VI. The Selection and Operation of Source Sampling Equipment	3	6
VII. Site Selection and Preparation	2	6
VIII. Data Collection and Reduction	2	3
IX. Introduction to Particulate Source Sampling	8	54
Total	32	96

I. Review of Ambient Sampling Principles
  A. Units of instruction
    1. Reasons for ambient sampling
    2. Quantitative determination of atmospheric pollutants
    3. Determination of sample size
    4. Determination of sampling rate
    5. Determination of sampling time
  B. Laboratory projects
    Continue the community air sampling survey initiated in "Air Pollution Sampling and Analysis I".

II. Sampling Specific Ambient Air Pollutants

  A. Units of instruction
    1. Sampling fluorides
      a. Absorption by sodium hydroxide solution
      b. Vegetation sampling
      c. Paper filter samplers
    2. Sampling chlorine compounds
    3. Sampling ammonium compounds
    4. Sampling organic compounds
      a. Freeze-out technique
      b. Wet collection methods
      c. Grab samples
      d. Analysis of samples
  B. Laboratory projects
    Continue community air sampling survey. Add sampling apparatus for some of the specific pollutants listed above.

III. Introduction to Source Sampling

  A. Units of instruction
    1. Objectives of testing
      a. Compliance with regulations
      b. Issuance of permits

c. Determining control equipment requirements
d. Efficiency of control equipment
e. Determining emission factors
2. Source sampling requirements
  a. Representative sample
  b. Known sample volume
  c. Known total gas flow rate
3. General considerations for source sampling
  a. Background information
  b. Special sampling requirements
  c. Selecting test procedures
  d. Scheduling tests
  e. Measuring effluent gas flow rate
  f. Collecting the samples
  g. Analyzing the samples
  h. Calculations
  i. Reports

B. Laboratory projects
1. Continue community survey
2. Study local or state regulations for air pollution
3. Study state permit systems
4. Study samples of source test requests and reports

IV. The Ideal Gas Laws and Psychrometry

A. Units of instruction
1. Ideal gas laws
  a. Boyle's Law
  b. Charles' Law
  c. General gas law
2. Dalton's Law of partial pressures
3. Measurement of gas pressure and temperature
  a. Thermometers and thermocouples
  b. Bourdon pressure gages
  c. Manometers
4. Psychrometry
  a. Water vapor pressure (saturation)
  b. Wet-dry bulb method
  c. The Carrier equation
  d. The psychrometric chart
  e. Condensation method

B. Laboratory projects
1. Using fan test apparatus, determine the moisture content of the gas stream using wet and dry-bulb thermometers.
2. Set up the apparatus necessary to measure the moisture content of a gas stream by the condensation method.

V. The Measurement of Gas Velocities and Flow Rates

A. Units of instruction
1. Gas flow measurements
  a. Location of test ports
  b. Velocity measuring devices
    (1) Standard type pitot tube
    (2) Stauscheibe pitot tube
    (3) Miscellaneous devices
  c. Flow measurements
    (1) Determining cross sectional area
    (2) Determining number of test points
    (3) The pitot traverse
    (4) Calibration of flow measuring devices
    (5) Other considerations
      (a) Testing for leaks
      (b) Manometer connections
      (c) Clogging of pitot tube
      (d) Sealing the sample port
      (e) Static pressure measurements
2. Gas flow calculations
  a. Velocity head (pressure)
  b. Gas velocity
  c. Standard pressure and density
  d. The flue factor
  e. Pressure corrections
  f. Density corrections

B. Laboratory projects
1. Using fan test apparatus, calibrate an S-type pitot tube. Determine the number and location of test points. Correct the flow rate for differences in density and static pressure.
2. Examine carefully the following devices:
  a. Anemometer
  b. Orifice meter
  c. Venturi meter
  Study the calibration method and operation of these instruments. Make notes of their uses and limitations.
3. Select a source to be tested in the field. Make a preliminary visit to the source and determine the gas flow rate at the source.

VI. The Selection and Operation of Source Sampling Equipment

A. Units of instruction
1. Preliminary considerations
  a. Site visit
  b. Inspection of process flow diagrams
  c. Process material balance
  d. Preliminary gas measurements
    (1) Flow rates
    (2) Temperature
    (3) Pressure

- (4) Moisture content
- e. Estimate of the nature of the emissions
- 2. Considerations for selecting equipment
  - a. Gas velocity at source
  - b. Temperature and moisture content of source gases
  - c. Type of pollutant to be measured
  - d. Estimated concentrations of pollutants
- 3. Source sampling equipment
  - a. Particulate sampling
    - (1) Probes and nozzles
    - (2) Collection devices
      - (a) Wet impingers
      - (b) Paper thimbles
      - (c) Alundum thimble filters
      - (d) Inertial separators
      - (e) Electrical precipitators
      - (f) Dry impingers
    - (3) Flow metering equipment
      - (a) Dry gas meter
      - (b) Wet test meter
      - (c) Calibrations
    - (4) Vacuum pumps
  - b. Sampling gaseous pollutants
    - (1) Grab samples
    - (2) Absorption and adsorption trains

B. Laboratory projects

- 1. Study the process flow diagrams for the source to be sampled. Collect samples of material input. Collect material balance data on process, if available, and estimate stack losses. What types of pollutants are expected?
- 2. Assemble a sampling train for sampling particulates and gaseous pollutants. Use an alundum thimble filter for collecting the particulates.
- 3. Calibrate a dry gas meter using a standard meter.
- 4. Examine the various devices available for grab sampling. Study the methods used to collect samples with these devices.
- 5. Examine several types of absorbers used in absorption trains.

VII. Site Selection and Preparation

A. Units of instruction

- 1. Criteria for site selection
  - a. Obtain representative gas sample
  - b. Accessibility
  - c. Access to utilities
  - d. Sample site location conducive to accurate gas flow measurement
  - e. Sample site location in relation to air pollution control equipment
- 2. Preparation of sample site
  - a. Construction of scaffolding
  - b. Providing utilities
  - c. Providing sample ports

B. Laboratory projects

Select a sample site at the source to be tested and prepare it for sampling particulates.

VIII. Data Collection and Reduction

A. Units of instruction

- 1. Tests in the field
  - a. Source information
    - (1) Material balances
    - (2) Operating conditions
    - (3) Gas flow rates
  - b. Sampling information
    - (1) Location of sampling stations
    - (2) Conditions at sample port
    - (3) Sampling rate
    - (4) Sampling time
    - (5) Conditions of gas in the sampling apparatus
- 2. Analytical information
  - a. Calculation of concentrations
  - b. Calculation of emission rates
  - c. Use of standard conditions
- 3. Reports
  - a. Requests for source tests
  - b. General form of reports
    - (1) Introduction
      - (a) Purpose of test
      - (b) Process tested
      - (c) Name and location of company tested
      - (d) Date of test
      - (e) Operating conditions during test
      - (f) Sampling port location
    - (2) Summary of results
      - (a) Presentation of principle test results
      - (b) Significance of results
      - (c) Description of samples
    - (3) Process description
      - (a) Process equipment
      - (b) Operating parameters
      - (c) Material description
      - (d) Material balance
    - (4) Sampling and analytical procedures
      - (a) Description of methods
      - (b) Description of modifications

        - (5) Tabular presentation of data
        - (6) Gross evaluation of data
            - (a) Checking calculations
            - (b) Comparing results with material loss rates
            - (c) Comparing results with data based on emission factors
- B. Laboratory projects
    - 1. Prepare a request for a source test on the source selected for sampling.
    - 2. Begin the field test report using the information previously collected.

IX. Introduction to Particulate Source Sampling

- A. Units of instruction
    - 1. Obtaining representative samples
        - a. Uniform dispersion of particles in the gas stream
        - b. Isokinetic sampling rates
        - c. Sampling port location
        - d. Sample volume
    - 2. Sampling train configurations
        - a. Probes and nozzles
        - b. Collection devices
        - c. Flow measuring device
        - d. Prime air mover
    - 3. Sampling considerations
        - a. Preliminary preparations
            - (1) Tare weights of filters
            - (2) Loading of impingers
            - (3) Assembling sampling train at site
        - b. Selection of nozzle
            - (1) Metered gas flow rate equation
            - (2) Constraints
                - (a) Flow needed for collection device
                - (b) Minimum diameter of nozzle to prevent clogging
        - c. Isokinetic sampling rate calculations
        - d. Sampling procedure
            - (1) Check operation of equipment
            - (2) Initial readings
            - (3) Record operating conditions
            - (4) Sampling time
            - (5) Final readings
            - (6) Equipment cleaning and repair
    - 4. Analytical methods
        - a. Filter weight difference
        - b. Separation of insoluble solids from wet samples
        - c. Filtrate evaporation for soluble solids
        - d. Total solids determination
        - e. Microscopic examinations
        - f. Analysis by electronic counters
    - 5. Calculation of results
        - a. Volume of stack gas sampled
        - b. Concentration of pollutants
        - c. Water vapor content of stack gas
        - d. Corrected stack gas flow rate
        - e. Mass rate of particulates from source
    - 6. Visual comparison methods of studying particulate emissions
        - a. Ringelmann Chart
        - b. Smokescope (umbrascope)
        - c. Equivalent Ringelmann opacity
- B. Laboratory projects
    - 1. Sample a source with a sampling train and determine the concentration of particulates in the emitted gases.
    - 2. Using a Ringelmann Chart and a smoke scope, determine the opacity of the source of particulates under study.

Texts and References

AIR POLLUTION CONTROL DISTRICT, COUNTY OF LOS ANGELES. *Laboratory Methods.*

AMERICAN SOCIETY OF MECHANICAL ENGINEERS. *Power Test Code.*

DEVORKIN AND OTHERS. *Source Testing Manual.*

HAALAND. *Methods for Determination of Velocity, Volume, Dust and Mist Content of Gases.*

PERRY. *Chemical Engineer's Handbook.*

SHEEHY AND OTHERS. *Handbook of Air Pollution.*

STERN. *Air Pollution,* Vol. 2.

Industrial and Engineering Chemistry.

Journal of the Air Pollution Control Association.

Visual Aids

U. S. Environmental Protection Agency, Technical Audio-Visual Branch, Research Triangle Park, N.C. 27711.

Source Sampling Equipment, MA51, 16 mm., 10 min., color, silent.

Reading Visible Emissions, MA48, 16 mm., 3 min., color, sound.

SOURCES OF AIR POLLUTION

Hours Per Week

Class, 3

Description

Basic to an understanding of the production and emission of air pollutants is the necessity for an introduction to the major industrial processes and energy-producing reactions. The raw materials, ancillary chemicals and supplies, type of processing and equipment used by an industry in the manufacture of its product may all be contributing factors to the kinds and quantities of pollutants emitted to the atmosphere. In this course, some of the basic methods of carrying out various industrial processes are studied. This general introduction is followed by a consideration of various stationary and mobile combustion (energy-producing) processes. Major industries such as chemical processing, petroleum, metals production, pulp and paper and food and feed are studied in some detail. This allows the student to achieve an understanding of specific problems relating to the control of air pollution within that industry. Finally, the methods of preparation and uses of source emission inventories are examined. Preparation of an actual emission inventory in an abbreviated form will provide experience in the use of this important tool.

Major Divisions

		Class Hours
I.	Industrial Processes	4
II.	Stationary Combustion Sources	5
III.	Mobile Combustion Sources	4
IV.	Petroleum Industry	4
V.	Chemical Process Industries	5
VI.	Nonmetallic Mineral Products Industries	4
VII.	Metallurgical Processes	5
VIII.	Pulp and Paper Industry	4
IX.	Food and Feed Industries	4
X.	Preparation and Use of Source Emission Inventories	9
		48

I. Industrial Processes

A. Process nomenclature and symbols
1. Process equipment
a. Vessels
b. Heat transfer equipment
c. Pumps, compressors, and fans
d. Miscellaneous equipment
(1) Centrifuges
(2) Crushers and grinders
(3) Filters
(4) Conveyors
2. Piping
a. Pipe sizes
b. Materials of construction
c. Pipe fittings
d. Valves
3. Process instruments
a. Primary sensing phases
b. Control systems
4. Utilities
a. Primary
(1) Water
(2) Fuel
(3) Power and process steam
(4) Storage and movement of raw materials and products
b. Secondary
(1) Maintenance
(2) Plant buildings
(3) Waste disposal system
B. Reading and interpreting flow diagrams
1. Schematic flow diagrams
2. Block flow diagrams
3. Process flow diagrams
4. Graphic diagram
5. Notations
6. Plot plans

II. Stationary Combustion Sources

A. Introduction
1. Total emissions on a nationwide level
2. Nature of emissions from stationary combustion sources
B. Solid fuel combustion
1. Types of solid fuels
a. Coke
b. Coal
c. Wood
2. Historical review of coal utilization
3. Description and size ranges of coal fired equipment
4. Combustion theory
5. Smoke emissions from coal-fired units
a. Operating variables affecting emissions
b. Detection and control of smoke
6. Particulate emissions from coal-fired units
a. Nature of particulate emissions
b. Operating variables affecting emissions
c. Detection and control of particulates
d. Typical emission factors
7. Gaseous emissions from coal-fired units
a. Nature of gaseous emissions
b. Operating variables affecting emissions

    c. Detection and control of gaseous emissions
    d. Typical emission factors
C. Fuel oil combustion
  1. Classification of fuel oils by grade and usage
    a. Pot type burners (ASTM No. 1)
    b. General purpose domestic heating (ASTM No. 2)
    c. ASTM Grades No. 4, 5, and 6
    d. Diesel Fuel
  2. Historical review of oil utilization
  3. Description and size ranges of oil-fired equipment
  4. Combustion theory
  5. Particulate and smoke emissions from oil-fired units
    a. Nature of emissions
    b. Operating variables affecting emissions
    c. Detection and control of emission
    d. Typical emission factors
  6. Acidic smut formation
    a. Operating variables affecting emissions
    b. Detection and control of emissions
  7. Gaseous emissions from oil-fired units
    a. Nature of gaseous emissions
    b. Operating variables affecting emissions
    c. Detection and control of emissions
    d. Typical emission factors
D. Gas-burning sources
  1. Classification of fuel gases
    a. Natural gas
    b. Blast furnace gas
    c. Oil gas
    d. Coal gas
    e. Coke-oven gas
  2. Utilization of fuel gases
    a. Auxiliary incinerator fuels
    b. Domestic and commercial heating
    c. Steam generation
  3. Particulate emissions from gas-fired units
    a. Nature of particulate emissions
    b. Operating variables affecting emissions
    c. Detection and control of emissions
    d. Typical emission factors
  4. Gaseous emissions from gas-fired units
    a. Nature of gaseous emissions
    b. Operating variables affecting emissions
    c. Detection and control of emissions
    d. Typical emission factors
E. Incinerators
  1. Types of incinerators
    a. In-line
    b. Retort
    c. Single chamber
    d. Mulftple chamber
  2. Description and sizes of incinerators
    a. Flue-fed incinerators
    b. Domestic incinerators
    c. Special industrial incinerators
    d. Industrial and municipal incinerators
  3. Particulate and gaseous emissions from incinerators
    a. Nature of emissions
    b. Operating variables affecting emissions
    c. Detection and control of emissions
    d. Typical emission factors
F. Fires
  1. Open fires
  2. Open-pit burning
  3. Fireplaces

III. Mobile Combustion Sources

A. Introduction
  1. Total emissions on a nationwide level
  2. Nature of emissions from mobile combustion sources
B. Emissions from gasoline-powered machinery
  1. Exhaust emissions
  2. Emissions via crankcase blow-by
  3. Emissions due to evaporation
  4. Photochemical reactions of hydrocarbon emissions
  5. Inspecting and certifying gasoline-powered vehicles
  6. Control systems for internal combustion engines
C. Emissions from diesel-powered machinery
  1. Nature of diesel emissions
  2. Operating variables affecting emissions
D. Gas Turbine Emissions
  1. Automotive
  2. Aircraft

IV. Petroleum Industry

A. Introduction
  1. Total emissions on a nationwide level
  2. Nature of emissions from the petroleum industry
B. Sources of air pollution in the petroleum industry

1. Crude oil production
2. Waste-gas disposal systems
3. Storage vessels
4. Loading facilities
5. Catalyst regeneration
6. Oil-water effluent systems
7. Pumps
8. Valves
9. Cooling towers

V. Chemical Process Industries

A. Mineral acids
   1. Sulfuric acid manufacturing
      a. Processes
         (1) Raw materials
         (2) Chamber process
         (3) Contact process
      b. Emissions from sulfuric acid manufacturing
         (1) Nitrogen oxides
         (2) Sulfur oxides
         (3) Sulfuric acid mist and spray
      c. Sampling and analytical techniques
   2. Phosphoric acid manufacturing
      a. Thermal-process phosphoric acid manufacturing
         (1) Raw materials
         (2) Process description
         (3) Yields and losses
      b. Emissions from phosphoric acid manufacturing
         (1) Acid mists
         (2) Oxides of nitrogen
         (3) Acid treating—H_2S
      c. Operating factors affecting emissions
      d. Sampling and analytical techniques
   3. Nitric acid manufacturing
      a. Chemical process
         (1) Chemistry of the process
         (2) Pressure processes
         (3) Other processes
         (4) Acid concentration processes
      b. Emissions from nitric acid manufacturing
         (1) Oxides of nitrogen
         (2) Nitric acid mist
      c. Sampling and analytical techniques

B. Miscellaneous chemical process industries
   1. Pharmaceutical industry
   2. Glass manufacturing
   3. Insecticide manufacturing
   4. Oil and solvent re-refining
   5. Radioactive materials

VI. Nonmetallic Mineral Products Industries

A. Construction materials
   1. Hot mix asphalt paving batch plants
   2. Concrete-batching plants
   3. Cement handling equipment
   4. Rock and gravel aggregate plants
B. Miscellaneous mineral products industries
   1. Mining operations
   2. Size reduction and classification
   3. Glass and ceramics manufacturing
   4. Asbestos processing

VII. Metallurgical Processes

A. Ferrous processes
   1. Steel manufacturing processes
      a. Open hearth furnaces
         (1) Nature of emissions
         (2) Sampling techniques
         (3) Control of emissions
      b. Electric arc furnaces
         (1) Nature of emissions
         (2) Sampling techniques
         (3) Control of emissions
      c. Electric induction furnaces
         (1) Nature of emissions
         (2) Sampling techniques
         (3) Control of emissions
   2. Iron casting
      a. Cupola furnaces
         (1) Nature of emissions
         (2) Sampling techniques
         (3) Control of emissions
      b. Electric-arc furnaces
         (1) Nature of emissions
         (2) Sampling techniques
         (3) Control emissions
      c. Induction furnaces
      d. Reverberatory furnaces
B. Non-ferrous processes
   1. Brass and bronze smelting and refining
      a. Furnace types
      b. Characteristics of emissions
      c. Hooding and ventilation requirements
      d. Air pollution control equipment
   2. Secondary aluminum-melting processes
      a. Furnace types
         (1) Crucible furnaces
         (2) Reverberatory furnaces
         (3) Fuel-fired furnaces
         (4) Electrically heated furnaces
      b. Characteristics of emissions
      c. Hooding and ventilation requirements

d. Air pollution control equipment
3. Secondary zinc-melting processes
a. Furnace types
(1) Reduction retort furnaces
(2) Distillation retort furnaces
(3) Muffle furnaces
b. Characteristics of emissions
c. Hooding and ventilation requirements
d. Air pollution control equipment
4. Lead refining
a. Furnace types
(1) Reverberatory furnaces
(2) Lead blast furnaces
(3) Pot-type furnaces
(4) Barton process
b. Characteristics of emissions
c. Hooding and ventilation requirements
d. Air pollution control equipment
5. Miscellaneous processes
a. Metal separation processes
b. Core ovens
c. Foundry sand-handling equipment
d. Heat treating systems
e. Production and purification of mercury

VIII. Pulp and Paper Industry

A. Kraft pulping process
1. Major sources of air pollution
a. Digester relief blow gas
b. Evaporator noncondensibles
c. Recovery furnace flue gas
d. Flue gas in direct contact evaporator
e. Flue gas in precipitator
f. Stack gas
g. Lime kiln gas
h. Odorous liquid effluent
2. Characteristics of emissions
a. Methyl mercaptan
b. Methyl sulfide
c. Methyl disulfide
d. Hydrogen sulfide
e. Sulfur dioxide
f. Particulate matter
3. Air pollution abatement
a. Scrubbing
b. Electrostatic precipitators
c. Process alternatives
B. Sulfite pulping process
1. Emissions compared to Kraft pulping process emissions
a. Gaseous pollutants
b. Particulate emissions
2. Characteristics of emissions
3. Air pollution abatement

IX. Food and Feed Industries

A. Feed and grain mills
1. Characteristic emissions
2. Sampling techniques
3. Air pollution abatement
B. Food processing
1. Coffee processing
2. Smokehouses
3. Deep fat frying
4. Livestock slaughtering
5. Fish canning and reduction plants
6. Edible-lard and tallow rendering
7. Bakeries
C. Miscellaneous sources
1. Crop spraying (insecticides)
2. Agricultural operations
3. Odors from pastures and feed lots
4. Open burning

X. Preparation and Use of Source Emission Inventories

A. Rapid survey techniques
1. Reporting zones
a. Selection of zones
(1) Land-use
(2) Fuel-use
(3) Topography
(4) Population density
b. Number of zones
c. Reporting zone map
2. Classification of sources
a. Stationary combustion sources
(1) Fuel-use inventory
(2) Fuel-use rates
(3) Distribution of fuel use to reporting zones
b. Mobile combustion sources
(1) Gasoline use
(2) Diesel fuel use
c. Refuse combustion sources
d. Industrial process losses
3. Estimation of pollutant emissions
a. Emission factors
(1) Oxides of sulfur
(2) Oxides of nitrogen
(3) Hydrocarbons
(4) Particulates
b. Calculation procedures
4. Interpretation of results
a. Presentation of data
b. Percentage of total pollutants by fuel use

        c. Percentage of total pollutants by category use
        d. Comparison of point and area sources
B. Other methods of preparing emission inventories
    1. Estimation of emissions in a regional air pollution control district

    2. Industrial and fuel use questionnaires
    3. Confidential industrial questionnaires
    4. Computer source inventories

Texts and References

BRASS AND BRONZE INGOT INSTITUTE. *Air Pollution Aspects of Brass and Bronze Smelting and Refining Industry.*

CUFFE AND GERSTLE. *Emissions from Coal-Fired Power Plants: A Comprehensive Summary.*

DANIELSON. *Air Pollution Engineering Manual.*

DUPREY. *Compilation of Air Pollutant Emission Factors.*

HENDRICKSON. *Atmospheric Emissions from Sulfate Pulping.*

LUND. *Industrial Pollution Control Handbook.*

MANUFACTURING CHEMISTS ASSOCIATION. *Atmospheric Emissions from Nitric Acid Manufacturing Processes.*

OZOLINS AND SMITH. *A Rapid Survey Technique for Estimating Community Air Pollution Emissions.*

SCHUENEMAN AND OTHERS. *Air Pollution Aspects of the Iron and Steel Industry.*

STERN. *Air Pollution*, Vol. 3.

Visual Aids

U. S. Environmental Protection Agency, Technical Audio-Visual Branch, Research Triangle Park, N.C. 27711.

After the Smoke Clears, MA-78, 16 mm., 15 min., color, sound.

Calculation of Estimated Emissions, MA-45, TV Tape, 20 min., Kinescope.

Source Inventory, MA-40, 16 mm., 15 min., b/w, sound.

Sources of Air Pollution, MA-15, 16 mm., 5 min., color, sound.

Vehicle Emissions Control Story, MA-82, 16 mm., 25 min., color, sound.

AIR POLLUTION INSTRUMENTATION

Hours Per Week

Class, 2; Laboratory, 6

Description

The basic methods of making measurements are of great importance to the air pollution technician. Beginning with a consideration of measurement errors and standards, the student progresses to detailed studies of the measurement of gas pressure, temperature and flow, and the appropriate instrumentation for making these measurements. Different types of recorders are investigated to determine their applications and limitations. More sophisticated analytical instruments are considered as combinations of several kinds of systems, including electrical and electronic, chemical, mechanical and pneumatic. Instrument types which are particularly related to the measurement of air pollutants are studied in detail. Laboratory exercises emphasize the use and calibration of various instruments, as well as the limits of accuracy of such instruments.

Major Divisions

		Hours	
		Class	Laboratory
I.	Introduction to Measurement	2	6
II.	Pressure	3	9
III.	Temperature	3	6
IV.	Flow	3	9
V.	Measurement of Miscellaneous Gas Properties	3	12
VI.	Recorders	3	6
VII.	Integration of Pneumatic, Chemical, Mechanical and Electrical Systems	4	12
VIII.	Specialized Air Pollution Sampling Equipment	3	12
IX.	Analytical Instrumentation	3	12
X.	Gas Chromatography	3	6
XI.	Microscopy	2	6
	Total	32	96

I. Introduction to Measurement

A. Units of instruction
    1. Definitions
        a. Instrument
            (1) Sensing element
            (2) Transmitting means
            (3) Output or indicating element
        b. Measurement
            (1) Direct
            (2) Indirect
        c. Accuracy
        d. Precision
        e. Sensitivity
        f. Resolution
    2. Errors
        a. Systematic

(1) Static
(2) Dynamic
b. Random
3. Standards
B. Laboratory projects
1. Estimate accuracy and precision possible with the following instruments:
a. Thermometer
b. U-tube manometer and inclined manometer
c. Ruler or other similar measuring device
2. Estimate confidence intervals for sets of sample data
a. Temperature readings
b. Pressure readings
c. Length measurements
3. Plot sample data on the following types of graph paper indicating intervals of error
a. Cartesian coordinates
b. Semilog
c. Log-log

II. Pressure

A. Units of instruction
1. Definition of pressure
a. Unit area
b. Unit force
c. Psi., psf., inches of water (in.w.), inches of mercury (Hg)
d. Standards
2. Manometers
a. Open end
(1) U-tube
(2) Inclined
b. Differential
c. Manometer fluids
d. Reservoir
e. Vacuum
3. Pressure gages
a. Bourdon pressure gage
b. Diaphragm gage
c. Bellows gage
d. Magnehelic
e. Vacuum
4. Calibration, maintenance, and placement of pressure gases
a. Manometers
b. Bourdon-tube gages
c. Vacuum gages
B. Laboratory projects
1. Compare and calibrate the following pressure gages against known standards; then, make a series of pressure measurements.
a. Manometer
b. Bourdon-tube gage
c. Diaphragm gage
d. Bellows gage
e. Pirani gage (vacuum)
Standards:
5 to 5,000 psi, the dead-weight tester
low pressures, water or mercury manometers near vacuum, McLeod gage
2. Dismantle, clean, and study possible adjustments for the following gages
a. Manometer
b. Bourdon-tube gage
c. Bellows gage
d. Pirani gage (vacuum)

III. Temperature

A. Units of instruction
1. Temperature scales
a. Fahrenheit
b. Celsius (Centigrade)
c. Absolute (Rankine, Kelvin)
d. Conversion equations
2. Temperature measuring devices
a. Liquid filled thermometers
b. Gas thermometers (gas-filled)
c. Vapor-filled thermometers
d. Bimetallic elements
e. Thermocouples
f. Thermistors
g. Optical pyrometers
3. Installation of temperature measuring devices
a. Angle
b. Submerge (liquid-elevation correction)
c. Shielding
d. Calibration
B. Laboratory projects
1. Measure the boiling point temperature of different liquids with the gas-filled and liquid-filled thermometers.
2. Calibrate a liquid-filled thermometer and a bimetallic dial thermometer.
3. Demonstrate the use of several types of thermocouples by using them to make temperature measurements.

IV. Flow

A. Units of instruction
1. Primary elements
a. Orifice plates
b. Venturi tubes
c. Flow nozzles

    - d. Dall tubes
    - e. Rotameters
    - f. Dry gas meters
    - g. Wet-test meters
    - h. Pitot tubes
      - (1) Standard (conventional) type
      - (2) Reversed type
    - i. Hot-wire anemometers
    - j. Spirometers
    - k. Electromagnetic flowmeters
  - 2. Secondary elements
    - a. Manometer types
    - b. Mercury cylinders
  - 3. Positioning and installation of flow meters
    - a. Installing flanges
    - b. Positioning of taps
      - (1) Flange taps
      - (2) Vena-contracta taps
      - (3) Pipe taps
    - c. Locating ports for traverses
  - 4. Calibration of flow meters
    - a. Velocity and area measurements
    - b. Weight rate and density measurements
    - c. Calculation of discharge coefficients and correction factors
- B. Laboratory projects
  - 1. Compare the flow measurement of air by venturi meter, orifice plate, calibrated elbow or turn, and pitot traverse.
  - 2. Determine discharge coefficient of a venturi meter, an orifice plate, and a flow nozzle over a wide range of flow rates.
  - 3. Calibrate a dry gas meter with a wet-test meter or a spirometer.

V. Measurement of Miscellaneous Gas Properties

- A. Units of instruction
  - 1. Water vapor content
    - a. Absolute humidity
    - b. Relative humidity
      - (1) Psychrometers
      - (2) Hygrometers
    - c. Dew point
    - d. Proportion of water vapor in a gas stream
      - (1) Wet and dry-bulb temperature technique
      - (2) Condensation technique
  - 2. Orsat analysis of carrier gas
    - a. Percent carbon monoxide
    - b. Percent carbon dioxide
    - c. Percent oxygen and nitrogen
- B. Laboratory projects
  - 1. Determine the relative humidity of the classroom air using a sling psychrometer and a resistance-type hygrometer.
  - 2. Field test an incinerator stack for moisture content, CO, CO_2, and O_2 concentrations.
  - 3. Compare the wet and dry-bulb temperature method of moisture determination with the condensation technique.

VI. Recorders

- A. Units of instruction
  - 1. Types
    - a. Round-chart type
    - b. Strip chart
    - c. Electrical
    - d. Pneumatic
  - 2. Components
    - a. Case
    - b. Measuring device
    - c. Writing pen
    - d. Timing mechanism
    - e. Charts
    - f. Linkage
  - 3. Adjustments
    - a. Microscrew
    - b. Turn buckle
    - c. Slip-joint
    - d. Slit-hub
    - e. Coarse adjustment
    - f. Fine adjustment
- B. Laboratory projects
  - 1. Study the components of recorders and calibrate, utilizing pneumatic pressure and an electrical signal for the transmission of signals from primary devices.
  - 2. Change the cart and adjust the writing pen on a recorder.

VII. Integration of Pneumatic, Chemical, Mechanical, and Electrical Systems

- A. Units of instruction
  - 1. Electrical-mechanical systems
    - a. Recorders
    - b. Thermostatic controls
    - c. Switches
    - d. Meters
  - 2. Pneumatic-mechanical systems
    - a. Control valves
    - b. Liquid-level controls
    - c. Thermostatic controls
    - d. Recorder controllers

    c. Tape samplers
  3. Electrical-chemical-pneumatic systems
    a. Gas analyzers
    b. Gas chromatography
    c. Flame photometry
B. Laboratory projects
  1. Study the components of the following instruments isolating the components as to system type.
    a. Recorder
    b. Tape sampler
    c. Gas analyzer
  2. Study a troubleshooting manual for a piece of air pollution instrumentation.

VIII. Specialized Air Pollution Sampling Equipment

A. Units of instruction
  1. Automatic tape samplers
    a. Function
    b. Principle of operation
    c. Performance data
    d. Analysis of samples
  2. Dust counters
    a. Function
    b. Principle of operation
      (1) Photoelectric
      (2) Resistance type
    c. Performance data
  3. Gas analyzers
    a. Wet chemical types
    b. Flame ionization types
  4. Electrostatic precipitator sampler
    a. Function
    b. Principle of operation
    c. Performance data
    d. Analysis of samples
  5. Thermal precipitators
    a. Function
    b. Principle of operation
    c. Performance data
    d. Analysis of samples

B. Laboratory projects

  1. Make measurements of laboratory aerosol concentrations and aerosol size distributions with the following:
    a. An automatic tape sampler
    b. A dust counter

  2. Demonstrate the operation of the following instruments:
    a. A gas analyzer
    b. Electrostatic precipitator sampler

IX. Analytical Instrumentation

A. Units of instruction
  1. The potentiometer
    a. Null-balance principle
    b. Galvanometer
    c. Vacuum tube voltmeter
  2. The differential amplifier
    a. Principle of operation
    b. Solid state and vacuum tube amplifiers
  3. Absorption instrumentation
    a. Ultraviolet
    b. Visible
    c. Infrared
    d. Photometers
    e. Spectrometer: optical
    f. Spectrophotometer
  4. Emission spectroscopy
    a. d-c arc
    b. a-c arc
    c. a-c spark
    d. Flame photometers
  5. Refractometry
    a. Refractometers
    b. Applications
  6. Measurement of pH
    a. Basic principles
    b. Buffer solutions
    c. pH electrodes
    d. Potentiometer-amplifier circuit
B. Laboratory projects
  1. Operate a potentiometer.
  2. Demonstrate a spectrometer.
  3. Calibrate a pH meter and make some sample measurements.

Gas Chromatography

A. Units of instruction
  1. Principle of operation
  2. Components
    a. Pressure regulator and flow meter
    b. Sample injection system
    c. Separation column
    d. Thermal compartment
    e. Detection system
    f. Strip-chart recorder
  3. Chromatographic columns
    a. Derivatives of daitomaceous earth
    b. Other support materials
    c. Absorbents
      (1) Solid
      (2) Liquid
B. Laboratory projects
  1. Study the components of a gas chromatograph.

2. Inject a known sample into the gas chromatograph and determine the concentration of each sample component using the data from the gas chromatograph.

XI. Microscopy

A. Units of instruction
  1. The objective
  2. The eyepiece (ocular)
  3. Magnifying power
  4. Lighting
  5. Filer micrometer

B. Laboratory projects
  1. Study the parts of a microscope
  2. Observe a sample of particles with a microscope and size the particles using a micrometer.

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AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS. *Air Sampling Instruments*

BAUMEISTER. *Mark's Standard Handbook for Mechanical Engineers.*

CHIRONIS. *Machine Devices and Instrumentation*

CUSICK. *Flow Meter Engineering Handbook*

DEVORKIN. *Source Testing Manual.*

MARCUS AND LENK. *Measurements for Technicians*

PERRY. *Chemical Engineer's Handbook.*

RASE AND BARROW. *Project Engineering of Process Plants.*

WILLARD AND OTHERS. *Instrumental Methods of Analysis.*

Visual Aids

(Films are black and white, unless color is noted)

U. S. Environmental Protection Agency. Technical Audio-Visual Branch. Research Triangle Park. N.C. 27711.

Infrared Spectroscopy, MA7. 16 mm., 28 min., color, sound.

University of Illinois. Visual Aids Service. Division of University Extension. Champaign. Ill. 61820.

Principles of Chromatography, 50827. 16 mm., 20 min., color, sound.

Modern Chemistry, Lesson 18: Introduction to Gas Behavior, 80882. 16 mm., 30 min., sound.

Modern Chemistry, Lesson 19: Gas Pressure — Origin and Measurement, 80883. 16 mm., 30 min., sound.

Modern Chemistry, Lesson 20: Partial Pressures — Boyle's Law, 80884, 16 mm., 30 min., sound.

AIR POLLUTION CONTROL

Hours Per Week

Class, 3; Laboratory, 6

Description

An introduction to the control of air pollution considers such topics as control objectives and different approaches to meeting those objectives. Any given air pollution problem is usually composed of and influenced by many factors. These factors are considered in their relation to the selection of control equipment. Various classes of control equipment are studied, including mechanical collectors, filtration devices, wet collectors and electrostatic precipitators. Gas absorption, adsorption and incineration techniques are considered as solutions to certain pollution problems. Following a study of representative sources of certain types of air pollutants, specific equipment testing techniques are examined to determine the kinds of data required to evaluate the performance of control equipment. Laboratory time has been purposely maximized in order to provide adequate opportunity for field trips. Class visits to field installations of various control equipment types provide first-hand observations of the practical use of such equipment.

Major Divisions

	Hours	
	Class	*Laboratory*
I. Control Objectives	3	6
II. Control Schemes	2	6
III. Factors Affecting Control Equipment Selection	3	6
IV. Mechanical Collectors	5	9
V. Filtration	4	6
VI. Wet Collectors	4	9
VII. Electrostatic Precipitators	4	6
VIII. Gas Absorption and Adsorption Equipment	4	3
IX. Incineration	4	6
X. Sources of Air Pollution and Control	6	12
XI. Equipment Testing	6	24
XII. Waste Disposal	3	3
Total	48	96

I. Control Objectives

- A. Units of instruction
  - 1. Comply with statute requirements
  - 2. Obtain a "clear stack"
  - 3. Recover valuable economic materials
  - 4. Improve public relations
  - 5. Reduce ground level complaints of odors, vegetation damage, nuisances
- B. Laboratory projects
  - 1. Study local and state air pollution regulations.
  - 2. Review state and local air pollution problem areas.

II. Control Schemes

- A. Units of instruction
  - 1. Process change to control air pollution
  - 2. Systematic approaches for controlling particulates after generation
  - 3. Systematic approaches for controlling gaseous pollutants after generation
  - 4. Approaches combining particulate and gaseous pollutant control
- B. Laboratory projects
  - 1. Review the literature for approaches to air pollution control.
  - 2. Using an approach to air pollution control, discuss the application of this approach to a specific source of air pollution.

III. Control Equipment Selection

- A. Units of instruction
  - 1. Calculation of required efficiencies
  - 2. Selection of control equipment based on removal capabilities
  - 3. Selection of control equipment based on other factors
    - a. Cost
    - b. Space
    - c. Materials
    - d. Auxiliary utilities
- B. Laboratory projects
  - 1. Using a sample set of data for emissions from a local source of air pollution and using local air pollution regulations, determine the removal efficiency for control equipment to meet the local regulations.
  - 2. Review sources of cost data for air pollution control equipment.

IV. Mechanical Collectors

- A. Units of instruction
  - 1. Gravity settling chambers
    - a. Principles of operation
    - b. Construction
    - c. Applications
    - d. Typical efficiencies for specific applications
    - e. Limitations
    - f. Costs
    - g. Performance testing
  - 2. Cyclone collectors
    - a. Principles of operation
    - b. Construction
    - c. Applications
    - d. Typical efficiencies for specific applications
    - e. Limitations
    - f. Costs
    - g. Performance testing
  - 3. Impingment separators
    - a. Types
      - (1) Baffle type
      - (2) Jet type
    - b. Principles of operation
    - c. Construction
    - d. Applications
    - e. Typical efficiencies for specific applications
    - f. Limitations
    - g. Costs
    - h. Performance testing
  - 4. Dynamic precipitators
    - a. Principles of operation
    - b. Construction
    - c. Applications
    - d. Typical efficiencies for specific applications
    - e. Limitations
    - f. Costs
    - g. Performance testing
- Laboratory projects
  - 1. Make a field trip to an industry using one or more of the following air pollution controls:
    - a. Gravity settling chamber
    - b. Cyclone collector
    - c. Impingment separator
    - d. Dynamic precipitator
  - 2. Observe a performance test on one of the above air pollution controls

V. Filtration

- A. Units of instruction
  - 1. Deep bed and mat filters
    - a. Filtration theory
    - b. Filter resistance
    - c. Construction

- d. Applications
- e. Typical efficiencies for specific applications
- f. Limitations
- g. Costs
- h. Performance testing

- 2. Fabric filters
  - a. Flow area considerations
  - b. Fabrics
    - (1) Cotton
    - (2) Wool
    - (3) Synthetics
  - c. Applications
  - d. Typical efficiencies for specific applications
  - e. Limitations
  - f. Costs
  - g. Performance testing
- 3. High efficiency panel filter

- B. Laboratory projects
  - 1. Compare the effects of a dirty filter on the static pressure and the velocity head when located upstream and downstream of a centrifugal blower in a duct system. (Effect on blower work.)
  - 2. Using a set of sample data for a clean room operation, determine what type of filter would work best to control the particulate level. Determine what materials should be used for the filter and estimate a value for the filtration area.

VI. Wet Collectors

- A. Units of instruction
  - 1. Principles of operation
    - a. Impingment
    - b. Brownian motion diffusion
    - c. Humidification effects
    - d. Condensation effects
    - e. Agglomeration
    - f. Electrostatic attraction
    - g Contacting power concept
  - 2. Types of wet collectors
    - a. Chamer scrubbers
    - b. Cyclonic scrubbers
    - c. Venturi scrubbers
    - d. Mechanical scrubbers
    - e. Jet scrubbers
  - 3. Applications
  - 4. Limitations
  - 5. Costs
  - 6. Performance testing
- B. Laboratory projects
  - 1. Make field trips to nearby industries using wet collectors as a means of controlling air pollution.
  - 2. Examine typical performance data for a wet collector and size a unit to control emissions from a hypothetical source of air pollution.

VII. Electrostatic Precipitators

- A. Units of instruction
  - 1. Theory of performance
    - a. Particle charging
    - b. Particle collecting
    - c. Removal of collected dust
  - 2. Types of electrostatic precipitators
    - a. Low voltage
    - b. High voltage
  - 3. Applications
  - 4. Limitations
    - a. High humidity
    - b. Stability of gas flow
    - c. Gas temperature and composition
  - 5. Costs
  - 6. Performance testing
- B. Laboratory projects
  - 1. Make a field trip to an industry using an electrostatic precipitator to control air pollution
  - 2. Demonstrate a laboratory model of an electrostatic precipitator
  - 3. For a hypothetical electrostatic precipitator and hypothetical operating conditions, estimate the following:
    - a. Charging field and collecting field
    - b. Particle drift velocity
    - c. Theoretical efficiency

VIII. Gas Absorption and Adsorption Equipment

- A. Units of instruction
  - 1. Absorption of gases
    - a. Principles of gas absorption
    - b. Classification of equipment
      - (1) Packed towers
      - (2) Plate towers
      - (3) Spray chambers
      - (4) Jet scrubbers
      - (5) Venturi scrubbers
      - (6) Wet cell washers
    - c. General design considerations
      - (1) Tower heights and number of transfer units
      - (2) Liquid to gas ratio
      - (3) Selection of absorption media
      - (4) Vapor-liquid equilibrium data
      - (5) Applications
      - (6) Limitations

- (7) Costs
- d. Performance testing of absorption equipment
- 2. Adsorption of gases
  - a. Principles of gas adsorption
    - (1) Adsorption surface area
    - (2) Selection of adsorbate
  - b. Design parameters for dynamic systems
    - (1) Recirculating systems
    - (2) One-pass nonregenerative systems
    - (3) One pass regenerative systems
    - (4) Applications
    - (5) Limitations
    - (6) Costs
  - c. Performance testing adsorption equipment
- B. Laboratory projects
  - 1. Study some typical packings for packed towers.
    - a. Raschig rings
    - b. Pall rings
    - c. Berl saddles
    - d. Intalox saddles
  - 2. Study the relative surface area, porosity and particle size of the following adsorbents:
    - a. A sample of a relatively nonpolar adsorbent such as activated carbon
    - b. A sample of a polar adsorbent such as:
      - (1) Alumina
      - (2) Bauxite
      - (3) Molecular sieves
      - (4) Silica gel

IX. Incineration

- A. Units of instruction
  - 1. Direct flame combustion
    - a. The flame front
      - (1) Definitions
      - (2) Variables affecting the front
        - (a) Type of fuel
        - (b) Gas and burning velocities
        - (c) Air-fuel ratio
        - (d) Temperature of gas mixture
    - b. "3 T's" of combustion
      - (1) Time of reaction
      - (2) Temperature
      - (3) Turbulence
    - c. Limits of flammability
      - (1) Upper
      - (2) Lower
    - d. Combustion calculations
    - e. Afterburner design
      - (1) Small port burners
      - (2) Large port burners
      - (3) Radiant or tile port burners
      - (4) Combustion chamber
      - (5) Safety features
    - f. Applications
      - (1) Flares
      - (2) Coffee roasters
      - (3) Smoke houses
      - (4) Rubber curing
      - (5) Cupola gases
      - (6) Rendering plants
      - (7) Varnish kettles
      - (8) Enamel baking ovens
      - (9) Asphalt blowing
    - g. Limitations
      - (1) "Turn down ratio"
      - (2) Clogging of nozzles and ports
    - h. Costs
    - i. Performance testing
  - 2. Catalytic combustion
    - a. Principles of operation
      - (1) Function of catalyst
      - (2) Selection of catalyst
      - (3) The catalyst surface
      - (4) Catalytic ignition point
    - b. Operating variables
      - (1) Pressure drop
      - (2) Fuel consumption
      - (3) Regeneration
      - (4) Exhaust gas flow variations
    - c. Applications
      - (1) Foundry core baking ovens
      - (2) Rendering of fish oils and animal fats
      - (3) Chemical plants
      - (4) Plastics manufacturing
      - (5) Paint baking ovens
    - d. Limitations
      - (1) Clogging due to large particulate matter
      - (2) Inorganic solids
      - (3) Vaporized metals
    - e. Costs
    - f. Performance testing
- B. Laboratory projects
  - 1. Make a field trip to an industry using incineration as a means of controlling air pollution.
  - 2. For a hypothetical airstream containing odorous gases, assume the odor can be destroyed with a flame afterburner with an outlet temperature of 1500° F. Assume a typical natural gas is used with 10% excess air and calculate the quantity of gas needed to produce the outlet temperature.

X. Sources of Air Pollution and Control

- A. Units of instruction
  - 1. Steel industry
    - a. Cyclones
    - b. Gas scrubbers
    - c. Electrostatic precipitators
    - d. Baghouse filters
  - 2. Foundry operations
    - a. Gas scrubbers
    - b. Mechanical separators
    - c. Baghouse filters
  - 3. Plating operations
    - a. Fume washers
    - b. Packed tower fume scrubbers
    - c. Filters
  - 4. Chemical industry
    - a. Types of control dependent on specific process
    - b. Breadth of equipment used
  - 5. Textile mills
    - a. Traveling lint filters
    - b. Special air tunnels
  - 6. Food industry
    - a. Mechanical collectors
    - b. Incineration
    - c. Gas scrubbers
  - 7. Pharmaceutical industry
    - a. Gas scrubbers
    - b. Baghouse filters
    - c. Adsorption
    - d. Incineration
  - 8. Pulp and paper industry
    - a. Electrostatic precipitators
    - b. Venturi scrubber
- B. Laboratory projects
  Visit local industries, locate specific sources of air pollution, and note the types of controls being used.

XI. Equipment testing

- A. Units of instruction
  - 1. Testing related to the objectives of the control
  - 2. Types of efficiency tests
  - 3. Efficiency calculation techniques
  - 4. Standard and accepted testing codes
  - 5. Performance factors
    - a. Power consumption
    - b. Utilities consumption
    - c. Liquor consumption
    - d. Maintenance
    - e. Miscellaneous considerations
      - (1) Public relations
      - (2) Noise
      - (3) Odors from settling ponds
- B. Laboratory projects
  - 1. Plan a trip to plant where a performance test may be made on a unit of air pollution control equipment.
  - 2. Outline a test procedure for this unit.
  - 3. Perform the test on the unit.

XII. Waste Disposal

- A. Units of instruction
  - 1. Dry solids
  - 2. Filter bags
  - 3. Sludges
  - 4. Solid wastes
  - 5. Liquid wastes
- B. Laboratory projects
  Review each method of control studied in the course and determine what method of waste disposal might be used with each.

Texts and References

AMERICAN INDUSTRIAL HYGIENE ASSOCIATION. *Air Pollution Manual, Part II — Control Equipment.*
DANIELSON. *Air Pollution Engineering Manual.*
LUND. *Industrial Pollution Control Handbook.*
ROSS. *Industrial Waste Disposal.*
STERN. *Air Pollution*, Vol. 3.

Visual Aids

U. S. Environmental Protection Agency, Technical Audio Visual Branch, Research Triangle Park, N.C. 27711.
Collection of Particulate Matter in the Control of Air Pollution, MA39, 16 mm., 22 min., color, sound.
Combustion for Control of Gaseous Pollutants, MA57, 16 mm., 12 min., color, sound.
Control of Air Pollution, MA14, 16 mm., 5 min., color, sound.

AIR POLLUTION SAMPLING AND ANALYSIS III

Hours Per Week

Class, 2; Laboratory, 6

Description

The concluding course in the air pollution sampling and analysis sequence continues the study of source sampling methods and analytical procedures. A review of particulate sampling methods is followed by a study of gaseous sampling techniques. Specific pollutant analyses receive major emphasis as advanced source sampling projects. Laboratory periods again emphasize practical sampling situations and approaches to problem solving.

Major Divisions

	Hours Class	Hours Laboratory
I. Review of Particulate Source Sampling	1	12
II. Advanced Source Sampling Methods	2	6
III. Collection and Measurement Equipment for Gaseous Pollutants	3	6
IV. Source Sampling Ammonia and Ammonium Compounds	3	9
V. Source Sampling Organic Acids	3	6
VI. Source Sampling Aldehydes	3	9
VII. Source Sampling Oxides of Nitrogen	3	6
VIII. Source Sampling Fluorides	4	9
IX. Source Sampling Oxides of Sulfur	4	9
X. Source Sampling Hydrocarbons	3	12
XI. Source Sampling Chlorine and Chlorine Compounds	3	12
Total	32	96

I. Review of Particulate Source Sampling

A. Units of instruction
  1. Isokinetic sampling
  2. Sampling trains
  3. Analytical methods
  4. Calculation methods

B. Laboratory projects
Select another point source of particulates and perform a field test for determining the particulate concentration.

II. Advanced Source Sampling Methods

A. Units of instruction
  1. Wet collection
    a. Greenburg-Smith impingers
    b. Modified Greenburg-Smith impingers
    c. Other wet collection devices
  2. Dry collection
    a. Paper thimble filters
    b. Alundum thimble filters
    c. Miniature glass cyclones
    d. Electrical precipitators
    e. Single or multiple-jet impactors
  3. Specialized methods
    a. Cyclone-alundum thimble combination
    b. Cyclone-high volume filter sample combination
    c. Quantitative measurement of odors
  4. Analyses
    a. Wet chemical methods
    b. Solubility determination
    c. Combustibles and ash
    d. Particle size determinations

B. Laboratory projects
  1. Discuss methods of sampling when:
    a. A mixture of very large particles and very small particles exists
    b. A large quantity of particulate matter is needed for analysis
    c. The dust concentration is very low
    d. Microscopic analysis is required
    e. Classification by particle size is advantageous
    f. The stack gases are very moist
  2. Study an analytical scheme for processing particulate matter samples.

III. Collection and Measurement Equipment for Gaseous Pollutants

A. Units of Instruction
  1. Collection requirements
    a. Isokinetic sampling
    b. Sampling location restrictions
    c. Volume of gas sample
  2. Gaseous sample equipment
    a. Absorption trains
      (1) Nozzles and probes
      (2) Collection devices
      (3) Moisture trap
      (4) Flow metering device
      (5) Prime mover
    b. Evacuated containers
      (1) Applications
        (a) Poor contaminant absorption characteristics
        (b) Necessity for analysis by physical methods
      (2) Types
        (a) Gas collecting tubes
        (b) Flasks
    c. Liquid displacement devices
      (1) Applications
        (a) Continuous sampling
        (b) Grab sampling
      (2) Equipment description
    d. Portable gas analysis devices
      (1) Tutwiler apparatus
      (2) Orsat apparatus
      (3) Colorimetric gas testers

(4) Combustible gas indicators
(5) Flame ionization instruments

B. Laboratory projects
1. Assemble an absorption train.
2. Become familiar with the Orsat apparatus and perform several analyses.
3. Become familiar with several grab sampling devices and use them to obtain gas samples.

IV. Source Sampling Ammonia and Ammonium Compounds

A. Units of instruction
1. Conventional sampling train configuration
a. Nozzle and probe
b. Impingers in ice bath
c. Moisture trap
d. Gas meter
e. Prime mover
2. Absorbing media
a. Water
b. 5% hydrochloric acid solution
3. Analytical procedure
a. Reagent preparation
b. Kjeldahl distillation
c. Titration
4. Calculation of ammonia concentration

B. Laboratory projects
Using the fan test apparatus or similar equipment, introduce a known quantity of ammonia into the air stream and sample the duct effluent. Analyze the samples and compare the data with concentration expected based on the quantity of ammonia used.

V. Source Sampling Organic Acids

A. Units of instruction
1. Collection with a conventional sampling train
2. Absorbing media
a. 5% sodium hydroxide in first impinger
b. 5% sodium hydroxide in second impinger
3. Analytical procedure
a. Reagent preparation
b. Liquid-liquid extraction with ether
c. Titration with sodium hydroxide
4. Calculation of organic acid concentration

B. Laboratory projects
1. Study the equipment needed to sample and analyze for organic acids.
2. Perform an analysis on a prepared sample.

VI. Source Sampling Aldehydes

A. Units of instruction
1. Collection by grab sampling
2. 1% sodium bisulfite solution used as absorption medium
3. Analytical procedure
a. Reagent preparation
b. Titration with an iodine solution
4. Calculation of aldehyde concentration

B. Laboratory projects
Again using the fan test apparatus, inject a known quantity of formaldehyde into the gas stream. Sample the gas stream for aldehydes and determine the concentration of formaldehyde in the gas stream.

VII. Source Sampling Oxides of Nitrogen

A. Units of instruction
1. Collection by grab sampling
2. Absorbing media
a. Hydrogen peroxide
b. Sulfuric acid
3. Analytical procedure
a. Evaporation of sample to dryness
b. Colorimetric determination of concentration
4. Calculation of oxides of nitrogen concentration

B. Laboratory projects
Select a point source of air pollution from which one or more of the contaminants studied in this course are emitted and prepare for a source sampling test.

VIII. Source Sampling Fluorides

A. Units of instruction
1. Collection with a conventional sampling train
2. Absorption in sodium hydroxide
3. Analytical procedure
a. Evaporation
b. Neutralization (with perchloric acid)
c. Steam distillation
d. Titration of distillate (with thorium nitrate)
4. Calculation of fluoride concentration

B. Laboratory projects
Visit the source to be sampled and make

preliminary gas flow measurements and sample site preparations.

IX. Source Sampling Oxides of Sulfur

- A. Units of instruction
  - 1. Collection with a conventional sampling train preceded by a filter
  - 2. Absorption in sodium hydroxide
  - 3. Analytical procedure
    - a. Sulfur dioxide determination
    - b. Sulfuric acid determination
    - c. Total sulfates determination
  - 4. Calculation of pollutant concentrations
- B. Laboratory projects

  Prepare the reagents and assemble the equipment necessary for a source test.

X. Source Sampling Hydrocarbons

- A. Units of instruction
  - 1. Collection by grab sampling
  - 2. Analytical procedure
    - a. Infrared spectrophotometry
    - b. Combustion and volumetric analysis
    - c. Chromatograph—combustion—infrared method
  - 3. Calculation of hydrocarbon concentrations
- B. Laboratory projects

  Conduct a source test on the selected point source for the contaminants of interest.

XI. Source Sampling Chlorine and Chlorine Compounds

- A. Units of instruction
  - 1. Collection with conventional sampling train
  - 2. Absorbing media
    - a. Water at ambient temperature
    - b. Chilled sodium hydroxide
  - 3. Analytical procedure
    - a. Iodometric titration for free chlorine content
    - b. Alkalimetric titration for hydrochloric acid
  - 4. Calculation of chlorine-hydrochloric acid concentrations
- B. Laboratory projects

  Complete analysis of samples taken during source test, calculate the results, and prepare a report.

Texts and References

The same as the references for Air Pollution Sampling and Analysis II

MATHEMATICS AND SCIENCE COURSES

MATHEMATICS I

Hours Per Week

Class, 4

Description

The sequence and content of the mathematical subjects chosen support the remaining courses in air pollution taken concurrently. The course begins with a description of the types of numbers commonly used, including decimals, rational and real numbers. The student then receives extensive practice in operating with these numbers and converting them to percentages. A deeper understanding into the number system is gained through studying scientific notation and the powers of ten.

Algebra is introduced through a description of the cartesian coordinate system, the straight line and various practical computational techniques such as synthetic division. A deeper understanding of algebraic relations is gained through application of powers and roots to related problems.

The slide rule is introduced as soon as a need arises for appropriate efficient computation. The major scales of the slide rule are studied in detail, and its usefulness in solving practical problems is emphasized.

Major Divisions

		Class Hours
I.	Types of Numbers	13
II.	Algebraic Expressions	15
III.	The Cartesian Coordinate System	5
IV.	The Straight Line	7
V.	Powers and Roots	6
VI.	The Slide Rule	8
VII.	The Slide Rule Applied to Data Collection and Analysis	10
	Total	64

I. The Basic Arithmetic Operations

A. Types of numbers
1. Integers
2. Rational numbers
3. Decimals
4. Real numbers

B. Operations
1. Addition
2. Subtraction
3. Multiplication
4. Division

C. Conversions
1. Fraction—decimal
2. Percent—fraction
3. Percent—decimal

D. Powers of 10 and scientific notation

II. Algebraic Expressions and Operations

A. Binominal expressions—one variable
1. Addition and subtraction
2. Multiplication
3. Division
4. Factoring
5. Distributive law

B. Integral exponents
1. Multiplication
2. Division
3. Powers

C. Agebraic expression—several variables
1. Addition and subtraction
2. Multiplication
3. Division
4. Factoring

D. Synthetic multiplication

E. Synthetic division
1. Factoring
2. Determination of roots

III. The Cartesian Coordinate System

A. Axes in 2 and 3 dimensions
B. Distance between two points
C. Slope of a line
D. Intercepts of a line

IV. The Straight Line

A. Determining a line from 2 points

B. The slope intercept form
1. Equation
2. Graph

C. The two-point form
1. Equation
2. Graph

D. The intercept form
1. Equation

    2. Graph

V. Powers and Roots

- A. Powers
    - 1. Positive integers and zero
    - 2. Negative integers
    - 3. Basic operations
- B. Roots
    - 1. Square root
    - 2. Cube root
    - 3. Rational roots
    - 4. Basic operations

VI. The Slide Rule—Basic Scales

- A. Defining the scales
- B. Multiplication
- C. Division
- D. Squares and square roots
- E. Scientific notation

VII. The Slide Rule Applied to Data Collection and Analysis

- A. Problems involving multiplication and division
- B. Problems involving powers and roots
- C. Combining operations

Texts and References

BOKUSLON. *Analytic Geometry.*
HEINEMAN. *Plane Trigonometry.*
PAUL AND SHAENEL. *Contemporary Technical Mathematics with Calculus.*
PLACEK. *Technical Math with Calculus.*
PROTTER AND MARREY. *College Calculus with Analytic Geometry.*
RICE AND KNIGHT. *Technical Calculus and Analysis.*
STRANGE AND RICE. *Analytic Geometry and Calculus.*
WOOTEN AND DROOYAN. *Intermediate Algebra.*

MATHEMATICS II

Hours Per Week

Class, 4

Description

This course is a continuation of Mathematics I. The basic topics of trigonometry are introduced and studied in detail, with applications to problems in air pollution given a central role. In addition to further applications of the slide rule, the desk calculator is introduced at an early stage of the course to facilitate the handling of problems involving the collection and analysis of data.

A thorough treatment of elementary statistics provides the student with the tools to perform most of the analyses made in the field. Efficient statistical algorithims, designed for desk calculator implementation, are intensively studied.

The course concludes with a brief but practical survey of the concepts in the calculus having greatest utility. Numerical methods are introduced to enhance the practical application of the calculus to problem solving.

Major Divisions

		Class Hours
I.	Basic Concepts of Trigonometry	15
II.	Introduction to the Desk Calculator	6
III.	Collection of Data	4
IV.	Basic Statistics	18
V.	Implementation of Statistical Techniques on the Calculator	5
VI.	Concepts of the Calculus	11
VII.	Numerical Methods for Analyzing Data	5
	Total	64

I. Basic Concepts of Trigonometry

- A. Definition of functions
    - 1. Sin x
    - 2. Cos x
    - 3. Tan x
- B. The Basic Right Triangles
    - 1. 3-4-5 triangle and multiples
    - 2. 45-45-90 triangle
    - 3. 30-60-90 triangle
- C. The reciprocal functions
- D. Sketching the trigonometric curves
- E. The trigonometric identities
- F. The trig scales on the slide rule
- G. Applications to practical problems

II. Introduction to the Desk Calculator

- A. Addition and substraction
- B. Multiplication
- C. Division
- D. Combining operation

III. Collection of Data

- A. Frequency counts

- B. Sorting data
- C. Constructing histograms and other graphs
- D. Displaying data

IV. Basic Statistics

- A. Measures of central tendency
    - 1. Mean
    - 2. Median
    - 3. Mode
- B. Measures of variation
    - 1. Range
    - 2. Variance
    - 3. Standard deviation
- C. The normal curve
- D. Using a table of the normal distribution
- E. The binomial distribution
- F. Correlation
- G. Least squares (regression)
    - 1. Fitting a straight line
    - 2. Fitting a parabola
- H. Methods of sampling

V. Implementation of Statistical Techniques on the Calculator

- A. Computing the means, variances and standard deviations
- B. Correlation problems
- C. Curve fitting problems
    - 1. Data from a normal distribution
    - 2. Data from an unknown distribution
- D. Prediction problems
    - 1. Exact curve-fitting
    - 2. Rolling averages
    - 3. Least squares

VI. Concepts of the Calculus

- A. Definition of a derivative
- B. The first derivative
    - 1. Polynomials
    - 2. Trigonometric functions
    - 3. The exponential and log functions
- C. Higher derivatives
- D. Finding maximum and minimum points
- E. Definition of integration
- F. Computing the area under a curve
- G. Numerical integration, using the slide rule and the calculator

VII. Numerical Methods for Analyzing Data

- A. Methods for finding and comparing statistics
- B. Methods for correlating two or more variables
- C. Additional curve-fitting techniques
- D. Smoothing data techniques
- E. Data reduction methods

Texts and References

The same as the references for Mathematics I.

CHEMISTRY I

Hours Per Week

Class, 2; Laboratory, 3

Description

Selected fundamental concepts of chemistry with emphasis on the principles important in analytical laboratory work are studied in this introductory course. Lecture topics include scientific methodology and measurement, classification of matter with respect to physical and chemical properties, physical and chemical changes, interactions of chemical substances, generalizations and predictions based on the periodic table, nomenclature, stoichiometric relationships, properties of important classes of substances, the gas state, the halogens, and the nitrogen and sulfur families. Laboratory exercises emphasize safety and precision and include practical experiences in measurement techniques and physical and chemical separations as applied to problems of qualitative and quanitative analysis.

Major Divisions

	Hours	
	Class	*Laboratory*
I. Introduction	1	3
II. Fundamental Concepts	2	6
III. Atomic Theory and Structure	2	6
IV. The Elements: Periodic Classification	2	3
V. Compounds: Chemical Bonding	3	3
VI. Chemical Equations and		

	Stoichiometry	6	6
VII.	Oxygen	2	6
VIII.	Hydrogen	2	3
IX.	The Atmosphere	3	3
X.	The Gas State	4	3
XI.	The Halogens	2	3
XII.	The Nitrogen and Sulfur Families	3	3
	Total	32	48

I. Introduction

- A. Units of instruction
  - 1. Historical background of chemistry
  - 2. The scope and relevance of chemistry
  - 3. The methods of science
  - 4. Measurements, standards, and units
  - 5. Scientific notation
  - 6. Significant figures
  - 7. Problem solving and dimensional analysis
- B. Laboratory projects
  - 1. Standard procedures and safety
  - 2. Introduction to laboratory equipment and techniques
  - 3. Measurement: weight, volume, and temperature
  - 4. Accuracy and precision

II. Fundamental Concepts

- A. Units of instruction
  - 1. Classification of matter
  - 2. Physical states of matter
  - 3. Changes of state and physical equilibria
  - 4. Physical and chemical changes
  - 5. Physical and chemical properties
  - 6. Conservation of mass
  - 7. Conservation of energy
- B. Laboratory projects
  - 1. Techniques of separation
  - 2. Determining physical and chemical properties
  - 3. Distinguishing between physical and chemical changes

III. Atomic Theory and Structure

- A. Units of instruction
  - 1. Dalton's atomic theory
  - 2. The laws of definite and multiple proportions
  - 3. The electrical nature of matter
  - 4. The nuclear atom
  - 5. Modern concepts of atomic structure
  - 6. Atomic number and mass number
  - 7. Symbols and notation
  - 8. Isotopes and isotopic weight
  - 9. Relative atomic weights
  - 10. Gram-atomic weights
- B. Laboratory projects: None

IV. The Elements: Periodic Classification

- A. Units of instruction
  - 1. Abundance of the elements
  - 2. Development of the modern periodic table
  - 3. Periodicity of physical and chemical properties
  - 4. Periods and groups
  - 5. Electron distribution
  - 6. Valence and valence electrons
  - 7. Trends in the periodic table
  - 8. Major divisions of the table
  - 9. Uses and limitations of the table
- B. Laboratory projects
  - 1. Distinguishing properties of metals and nonmetals
  - 2. Typical reactions

V. Compounds: Chemical Bonding

- A. Units of instruction
  - 1. Electronegativity
  - 2. The electrovalent bond: ionic compounds
  - 3. The covalent bond: covalent compounds
  - 4. Polar covalent bonds
  - 5. Valence and oxidation number
  - 6. Complex ions
  - 7. Formulas
  - 8. Nomenclature
- B. Laboratory projects
  - 1. Distinguishing properties of ionic and covalent compounds
  - 2. Distinguishing properties of organic and inorganic compounds

VI. Chemical Equations and Stoichiometry

- A. Units of instruction
  - 1. Formulas and composition
  - 2. Types of chemical change
  - 3. Balancing chemical equations
  - 4. The mole concept
  - 5. Weight relationships
- B. Laboratory projects
  - 1. Reactions: direct combination, decomposition, single and double displacement

- 2. Quantitative analysis of a compound

VII. Oxygen

- A. Units of instruction
  - 1. Historical introduction
  - 2. Occurrence and properties
  - 3. Preparation
  - 4. Allotrophy: ozone
  - 5. Combustion and heat of reaction
  - 6. Applications
- B. Laboratory projects
  - 1. Preparation and properties of oxygen
  - 2. Reactions of oxygen: oxidation
  - 3. Properties of metal and nonmetal oxides

VIII. Hydrogen

- A. Units of instruction
  - 1. Historical introduction
  - 2. Occurrence and properties
  - 3. Preparation
  - 4. Isotopes of hydrogen: uses
  - 5. Oxidation and reduction
  - 6. Electrochemical series
  - 7. Applications
- B. Laboratory projects
  - 1. Preparation and properties of hydrogen
  - 2. Reactions of hydrogen: reduction

IX. The Atmosphere

- A. Units of instruction
  - 1. Introduction
  - 2. Composition of the atmosphere
  - 3. Density of the atmosphere
  - 4. Relative humidity
  - 5. Measurement of temperature and pressure
  - 6. Pollution of the atmosphere
  - 7. The oxygen cycle
  - 8. The carbon dioxide cycle
  - 9. The nitrogen cycle
  - 10. The noble gases
- B. Laboratory projects
  - Analysis of an air sample
    - a. Oxygen
    - b. Nitrogen
    - c. Carbon dioxide
    - d. Water

X. The Gas State

- A. Units of instruction
  - 1. Standard conditions
  - 2. Pressure, volume, and temperature relationships
  - 3. Partial pressure and partial volume
  - 4. Standard molar volume
  - 5. The gas constant, R
  - 6. Kinetic molecular theory
  - 7. Gaseous equilibria
  - 8. Ideal and real gases
  - 9. Problems and applications
- B. Laboratory projects
  - 1. Pressure, temperature, volume relationships of gases
  - 2. Preparation and collection of a gas sample: weight-volume relationships

XI. The Halogens

- A. Units of instruction
  - 1. Occurrence
  - 2. Preparation and properties
  - 3. Family trends
  - 4. Preparation and properties of the hydrogen halides and their salts
  - 5. Toxicity and hazards
- B. Laboratory projects
  - Identification of halides

XII. The Nitrogen and Sulfur Families

- A. Units of instruction
  - 1. Occurrence
  - 2. Preparation and properties
  - 3. Family trends
  - 4. Allotropy
  - 5. Preparation and properties of ammonia
  - 6. Preparation and properties of nitric acid
  - 7. Preparation and properties of sulfuric acid and sulfates
  - 8. Sulfur and its oxides in analysis and in pollution
  - 9. Photochemical reactions
  - 10. Toxicity and hazards
- B. Laboratory projects
  - 1. Identification of nitrites and nitrates
  - 2. Identification of sulfites and sulfates
  - 3. Gravimetric determination of sulfates

Texts and References

BIGELOW, *Basic Concepts of Chemistry.*
FREY, *College Chemistry.*
HARDWICK AND KNOBLER, *Chemistry: Man and Matter.*
OUELLETTE, *Introductory Chemistry.*
PAULING, *College Chemistry.*
SELWOOD, *General Chemistry.*
SIEBRING, *Chemistry.*

Visual Aids

(Films are 16 mm. with sound)

NET Film Service, Indiana University, Audio Visual Center, Bloomington, Ind. 47401.

Atmosphere and Its Circulation, 11 min., b/w

Atoms into Molecules, 29 min., b/w.

Chemical Families, 22 min., color.

Elements, Compounds and Mixtures, 33 min., color.

Equilibrium, 24 min., color.

Gases and How They Combine, 21 min., color.

Kinetic Molecular Theory, 8 min., b/w or color.

Nitric Acid and the Nitrogen Cycle, 18 min., b/w or color.

Oxygen, 11 min., b/w or color.

Safety in the Chemical Laboratory, 20 min., color.

Sulfur and Its Compounds, 13 min., b/w or color.

The Halogens, 16 min., b/w or color.

Visual Aids Service, University of Illinois, Division of University Extension, Champaign, Ill. 61820.

Ammonia, 18 min., b/w.

Phosphorus, 19 min., b/w.

Physical and Chemical Change, 28 min., b/w or color.

Preparation and Properties of Hydrogen, 18 min., b/w or color.

Sulfur Dioxide and Sulfurous Acid, 24 min., b/w

CHEMISTRY II

Hours Per Week

Class, 2; Laboratory, 3

Description

The second chemistry course deals with selected descriptive chemistry, sollution and colloid chemistry, ionic equilibria, and electrochemistry, with emphasis on the practical applications in laboratory work. Lecture topics include solutions and colloids, analytic applications of ionic equilibria, oxidation reduction reactions, galvanic cells, electrochemical corrosion, electrolysis, chemistry of the active metals, chemistry of the heavy metals, carbonates and silicates, nuclear chemistry, and organic and biological chemistry. Laboratory exercises include qualitative identification of selected anions, cations, and organic substances, and volumetric and gravimetric quantitative determinations of some important substances.

Major Divisions

	Hours	
	Class	*Laboratory*
I. Water: The Liquid State	3	6
II. Solutions and Colloids	4	6
III. Ionization: Acids, Bases, and Salts	3	6
IV. Introduction to Ionic Equilibria	3	3
V. Electrochemistry	3	3
VI. The Active Metals	2	3
VII. The Heavy Metals	2	3
VIII. Boron, Carbon, and Silicon	2	3
IX. Nuclear Chemistry	2	0
X. Organic and Biological Chemistry	8	15
Total	32	48

I. Water: The Liquid State
- A. Units of instruction
    1. Abundance of water
    2. The unique physical properties of water
    3. Hydrogen bonding
    4. Chemical properties of water
    5. Hydrates
    6. Deliquescence and efflorescence
    7. Water as a measurement standard
    8. Treatment and purification of natural waters
    9. Properties of liquids
- B. Laboratory projects
    1. Water in crystalline hydrates
    2. Deliquescence and efflorescence
    3. Distillation

II. Solutions and Colloids
- A. Units of instruction
    1. Types of solutions
    2. Components of solutions
    3. Solubility and equilibrium
    4. Factors affecting solubility
    5. Solution rate
    6. Expressing concentration
    7. Reactions in solution: calculations
    8. Colligative properties of solutions
    9. Distillation
    10. Solubility generalizations
    11. Partition
    12. Properties of colloids: aerosols
    13. Preparation and stabilization of colloids
    14. Precipitation of colloids
    15. Applications
- B. Laboratory projects
    1. The use of primary standards
    2. Preparation and standardization of solutions
    3. Precipitation titrations

III. Ionization: Acids, Bases, and Salts

- A. Units of instruction
  - 1. Electrolytes and nonelectrolytes
  - 2. Metallic and electrolytic conduction
  - 3. Dissociation and ionization
  - 4. The role of the solvent
  - 5. Strong and weak electrolytes
  - 6. Preparation of acids, bases, and salts
  - 7. Properties of acids, bases, and salts
  - 8. Reactions of acids, bases, and salts
  - 9. Neutralization and titration
  - 10. Equivalent weights and normality
  - 11. Applications
- B. Laboratory projects
  - 1. Properties of acids and bases
  - 2. Standardization of acids and bases
  - 3. Determination of the concentration of an unknown acid or base

IV. Introduction to Ionic Equilibria

- A. Units of instruction
  - 1. Weak acids and bases
  - 2. Ionization constants
  - 3. The ionization of water
  - 4. pH and pOH
  - 5. The common ion effect
  - 6. Buffers
  - 7. Hydrolysis
  - 8. Indicators
  - 9. Solubility product constants
  - 10. Dissolving precipitates
  - 11. Dissociation of complex ions
  - 12. Complex equilibria: application to analytical problems
- B. Laboratory projects
  - 1. pH measurements
  - 2. pH titrations
  - 3. Compleximetric titrations

V. Electrochemistry

- A. Units of instruction
  - 1. Oxidation-reduction
  - 2. Balancing redox equations
  - 3. Redox titrations
  - 4. Single electrode potentials
  - 5. Cell potentials
  - 6. Batteries
  - 7. Electrolysis and electroplating
  - 8. Analytical applications
  - 9. Electrochemical corrosion
- B. Laboratory projects
  - 1. Activity series of the metals
  - 2. Oxidation-reduction reactions and indicators
  - 3. Potentiometric titrations

VI. The Active Metals

- A. Units of instruction
  - 1. Typical physical and chemical properties of the metals
  - 2. The metallic bond
  - 3. Occurrence, preparation, and properties of the IA metals
  - 4. Occurrence, preparation, and properties of the IIA metals
  - 5. Occurrence, preparation, and properties of aluminum
  - 6. Amphoterism
  - 7. Applications
- B. Laboratory projects
  - 1. Properties of the IA and IIA metals and aluminum
  - 2. Identification of the IA and IIA metals and aluminum

VII. The Heavy Metals

- A. Units of instruction
  - 1. Iron and steel
  - 2. Corrosion prevention
  - 3. Alloy steels
  - 4. Occurrence, metallurgy, and properties of zinc, mercury, copper, silver, tin, and lead
  - 5. Important alloys
  - 6. Hazards and toxicity
  - 7. Identification reactions
- B. Laboratory projects

  Identification of some heavy metal cations
  - a. Lead
  - b. Mercury
  - c. Arsenic
  - d. Copper

VIII. Boron, Carbon, and Silicon

- A. Units of instruction
  - 1. Occurrence
  - 2. Preparation and properties
  - 3. Allotrophy
  - 4. The solid state
  - 5. Molecular solids and network solids
  - 6. The vitreous state
  - 7. Glasses, ceramics, and cement
  - 8. Silicates, carbonates, and borates
  - 9. Industrial hazards
  - 10. Analytical reactions
- B. Laboratory projects
  - 1. Analysis of a carbonate
  - 2. Identification of a silicate

IX. Nuclear Chemistry

- A. Units of instruction
  - 1. Radioactive decay
  - 2. Half life
  - 3. Radiocarbon dating
  - 4. Particle accelerators
  - 5. Artificial radioactivity
  - 6. Nuclear fission
  - 7. Nuclear fusion
  - 8. Mass-energy relationships
  - 9. The origin of the elements
  - 10. Radiation detection
  - 11. Hazards
  - 12. Applications
- B. Laboratory projects: none

X. Organic and Biological Chemistry

- A. Units of instruction
  - 1. Introduction
  - 2. Formulas, structure, and models
  - 3. Isomerism
  - 4. Homologous series
  - 5. Functional groups
  - 6. Sources of hydrocarbons
  - 7. Classification of hydrocarbons
  - 8. Nomenclature of hydrocarbons
  - 9. Reactions of hydrocarbons
  - 10. Hydrocarbons as pollutants
  - 11. Nomenclature, preparation, properties, and reactions of halogen, oxy, hydroxy, carbonyl, and carboxyl derivatives of hydrocarbons
  - 12. Uses and hazards
- B. Laboratory projects
  - 1. Properties of hydrocarbons
  - 2. Saponification and hydrolysis
  - 3. Identification of aldehydes and ketones

Texts and References

The same as the references for Chemistry I

Visual Aids

NET Film Service, Indiana University, Audio-Visual Center, Bloomington, Ind. 47401.
(The following films are 16 mm. with sound)

Acids, Bases and Salts, 21 min., b/w or color.
Carbon and Its Compounds, 11 min., b/w or color.
Electricity from Chemicals, 14 min., b/w or color.
Hydrocarbons and Their Structure, 12 min., b/w or color.
Metals and Nonmetals, 13 min., b/w or color.
Oxidation-Reduction, 10 min., color.
Properties of Water, 11 min., b/w or color.
Radioactivity, 12 min., color.
Solutions, 16 min., b/w or color.
The Colloidal State, 16 min., b/w or color.

Visual Aids Service, University of Illinois, Division of University Extension, Champaign, Ill. 61820.
(The following films are 16 mm. with sound)
Chemical Properties of Water, 13 min., b/w or color.
Ionic Equilibria, 16 min., b/w.
Ionization, 18 min., b/w or color.
Standard Solutions and Titration, 21 min., b/w.

PHYSICS I

Hours Per Week

Class, 2; Laboratory, 3

Description

This course is not a traditional survey course but is oriented toward developing skills such as the application of mathematics to physical models and toward the acquisition of a technical vocabulary. Enough conceptual framework is provided to insure a sound basis for work in more specialized courses. Laboratory work is stressed so that students will be able to use measuring devices and instrumentation, analyze data, and display it meaningfully. Atomic theory is studied before mechanics to allow students to make more progress in mathematics.

Major Divisions

		Hours	
		Class	*Laboratory*
I.	Basic Measurements	2	6
II.	Atomic Theory	4	0
III.	Physical Properties of Matter	6	15
IV.	Statics	2	6
V.	Kinematics—Rectilinear Motion	6	6
VI.	Dynamics	6	6
VII.	Angular Motion	2	3
VIII.	Work, Energy and Power	4	6
	Total	32	48

I. Basic Measurements

- A. Units of instruction
  - 1. Quantitative aspects of science
    - a. The relationship between science and mathematics
    - b. Systems of measurement
      - (1) English

(2) MKS
(3) CGS
c. Use of units in problem solutions: Dimensional Analysis
2. Methods of measurement
a. Standards
b. Calibration
c. Instrumentation
B. Laboratory projects
1. Length measuring devices including vernier and micrometer calipers.
2. Time measuring devices including the stop watch.
3. Statistical analysis of errors.
4. Use of the slide rule.

II. Atomic Theory

A. Units of instruction
1. The atomic hypothesis
a. Atoms
b. Elements
c. Chemical bonds
d. Molecules
e. Compounds
2. Forces among molecules
a. Adhesion
b. Cohesion
c. Capillarity
3. Molecular motion
a. Diffusion
b. Osmosis
B. Laboratory projects: None

III. Physical Properties of Matter

A. Units of instruction
1. Phase
2. Density
3. Specific gravity
4. Specific characteristics of solids
a. Elasticity
b. Young's modulus
c. Shear modulus
d. Bulk modulus
5. Specific characteristics of liquids
a. Pressure
b. Pascal's Law
c. Archimedes' Law
d. Viscosity
e. Surface tension
f. Fluid flow — Bernoulli's Eqn.
6. Specific properties of gases
a. Pressure
b. Pascal's Law
c. Archimedes' Law
d. Fluid flow — Bernoulli's Eqn.
B. Laboratory projects
1. Density from linear measurements
2. Elastic modulus of wire
3. Pressure measurements
a. Manometer—liquids
b. Barometer—gases
4. Archimedes' Law
5. Torsion pendulum

IV. Statics

A. Units of instruction
1. Vectors
a. Graphic representations and solutions
b. Simple analytical examples
2. Conditions for equilibrium of concurrent forces
3. Friction
4. Moments
B. Laboratory projects
1. Equilibrium of concurrent forces
2. Coefficient of friction

V. Kinematics—Rectilinear Motion

A. Units of instruction
1. Speed, distance, and time
2. Scalar and vector aspects of kinematic quantities
3. Velocity
4. Acceleration
5. Analysis of rectilinear motion
B. Laboratory projects
1. Projectile motion
2. Mathematical analysis of vector problems

VI. Dynamics

A. Units of instruction
1. Newton's first law
a. Mass
b. Inertia
2. Newton's second law
a. Force and motion
b. Reference frames
3. Newton's third law
B. Laboratory projects
1. Atwood's machine
2. Simple machines

VII. Angular Motion

A. Units of instruction
1. Center of [illegible]s
2. Circular moti[illegible]
3. Centripetal and centrifugal forces

B. Laboratory projects
   Centripetal force machine

VIII. Work, Energy, and Power

- A. Units of instruction
  - 1. Work
    - a. Definition and units
    - b. Forms of work
  - 2. Energy
    - a. Definition and units
      - (1) Kinetic
      - (2) Potential
    - b. Forms of energy
    - c. Conservation of energy
  - 3. Power
    - a. Definition and units
    - b. Power measurement
- B. Laboratory projects
  - 1. Conservation of energy
  - 2. Power measurement—Prony Brake

Texts and References

BEISER, *Modern Technical Physics.*
CONDON AND ODISHAW, *Handbook of Physics.*
HALLIDAY, *Physics for Students of Science and Engineering.*
HARRIS, *Experiments in Applied Physics.*
HARRIS AND HEMMERLING, *Introductory Applied Physics.*
HEWITT, *Conceptual Physics.*
JOSEPH AND OTHERS, *Physics for Engineering Technology.*
McCORMICK, *Fundamentals of University Physics.*
MILLER, *College Physics.*
POLLACK, *Applied Physics.*
SMITH AND COOPER, *Elements of Physics.*
WHITE AND OTHERS, *Practical Physics.*

Visual Aids

Association Films, 600 Madison Avenue, New York, N.Y. 10022.
The Kinetic Theory of Matter, 16 mm., 13 min., color, sound.

Coronet Instructional Films, 65 East Southwater Street, Chicago, Ill. 60601.
Engines and How They Work, 16 mm., 11 min., black and white, sound.
Forces: Composition and Resolution, 16 mm., 11 min., black and white, sound.
Inertial Mass and the Laws of Motion, 16 mm., 16 min., color, sound.
Laws of Gases, 16 mm., 11 min., black and white, sound.
Mass and Weight, 16 mm., 10 min., color, sound.
Metric System, 16 mm., 11 min., b/w or color, sound.
Specific Gravity and Archimedes' Principle, 16 mm., 11 min., black and white, sound.
Velocity and Acceleration, 16 mm., 11 min., black and white, sound.

Encyclopaedia Britannica Films, Inc., 1150 Wilmette Avenue, Wilmette, Ill. 60091.
Galileo's Laws of Falling Bodies, 16 mm., 6 min., black and white, sound.
How to Measure Time, 16 mm., 11 min., color, sound.
Laws of Motion, 16 mm., 12 min., color, sound.
Mechanics (Series of 11 films, lessons 7, 9, 12, 14, 17, 20, 28, 32, 42, 43, 44), 16 mm., 30 min., black and white, sound.
Properties of Matter (Series of 4 films, lessons 1, 8, 11, 13), 16 mm., 30 min., black and white, sound.
Units of Measurement, 16 mm., 30 min., black and white, sound.

McGraw Hill Book Company, Inc., 330 West 42nd Street, New York, N.Y. 10036.
Uniform Circular Motion, 16 mm., 8 min., black and white, sound.

University of Illinois, Visual Aids Service, Champaign, Ill. 61820.
The Atom: How Big Is An Atom?, 16 mm., 28 min., black and white, sound.
The Atom: What Makes Atoms Stick Together?, 16 mm., 27 min., black and white, sound.

PHYSICS II

Hours Per Week

Class, 3; Laboratory, 3

Description

This course introduces the basic physics of gases in enough detail to allow for qualitative understanding of atmospheric processes. Heat, kinetic theory, and thermodynamics are also developed with this in mind. Light, electricity, and magnetism are oriented toward preparing the student for using and understanding appropriate instrumentation as well as further technical study. Laboratory work is stressed with relevant equipment emphasized.

Major Divisions

	Hours	
	Class	*Laboratory*
I. Heat and Temperature	4	6
II. Heat Transfer	3	3
III. Thermal Properties of Gases	4	3
IV. Kinetic Theory of Gases	7	6
V. Electrostatics	3	3
VI. Current Electricity	6	6
VII. Magnetism	4	6
VIII. Direct Current Measurements	5	3
IX. Alternating Current Measurements	5	6
X. Light	3	3

XI. The Relationship between Thermal, Electrical and Mechanical Work, Energy, and Power	4	3
Total	48	48

I. Heat and Temperature

- A. Units of instruction
  - 1. Temperature
    - a. Common scales and units
    - b. Instrumentation
  - 2. Definition of heat energy
    - a. Heat capacity
    - b. Specific heat capacity
    - c. Latent heat
    - d. Change of state
- B. Laboratory projects
  - 1. Thermometer calibration
  - 2. Coefficient of linear expansion
  - 3. Specific heats of various solids

II. Heat Transfer

- A. Units of instruction
  - 1. Thermal equilibrium
  - 2. Heat transfer
    - a. Conduction
    - b. Convection
    - c. Radiation
  - 3. Instrumentation—pyrometers
- B. Laboratory projects
  - Newton's Law of cooling

III. Thermal Properties of Gases

- A. Units of instruction
  - 1. Avogadro's Law
  - 2. Boyle's Law
  - 3. Charles' Law
  - 4. Dalton's Law of partial pressures
  - 5. External work and thermal energy
- B. Laboratory projects
  - Boyle's and Charles' gas laws

IV. The Kinetic Theory of Gases

- A. Units of instruction
  - 1. Energy
  - 2. Pressure
  - 3. Real gases
    - a. Critical points
    - b. Liquefaction of gases
    - c. Fractional distillation
  - 4. The atmosphere
    - a. Origin
    - b. Composition
    - c. Vertical structure
    - d. Energy content
    - e. Weather and meteorology
- B. Laboratory projects
  - 1. Vapor pressure versus temperature of various liquids
  - 2. Measurement of relative and absolute humidities

V. Electrostatics

- A. Units of instruction
  - 1. Electric charge
    - a. Protons and electrons
    - b. Units
  - 2. Coulomb's Law
  - 3. Electrostatic induction
  - 4. Electric fields
  - 5. Potential difference
  - 6. The capacitor
- B. Laboratory projects
  - The force between two charged spheres

VI. Current Electricity

- A. Units of instruction
  - 1. Definition of current
    - a. Electron motion
    - b. Ion motion
    - c. Units
    - d. Direct and alternating currents
  - 2. Resistance
    - a. Resistivity
    - b. Conductors
    - c. Insulators
    - d. Semiconductors
  - 3. Electromotive force
    - a. Sources
    - b. Units
  - 4. Ohm's Law
  - 5. Electrical power
  - 6. Thermionic emission
  - 7. Common circuit elements
    - a. Capacitors
    - b. Inductors
    - c. Rheostat
- B. Laboratory projects
  - 1. Resistances in series and parallel
  - 2. Wheatstone bridge
  - 3. Ions in solution

VII. Magnetism

- A. Units of instruction
  - 1. Atomic Theory of magnetism
  - 2. Permanent and electromagnets
  - 3. Magnetic forces

4. Magnetic fields
5. Magnetic properties of matter
    a. Ferromagnetism
    b. Paramagnetism
    c. Diamagnetism
6. The earth's magnetic field
7. Electromagnetic induction

B. Laboratory projects
    1. Induced electromotive force
    2. The tangent galvanometer

VIII. Direct Current Measurements

A. Units of instruction
    1. DC meters and instruments
        a. Tuning coil instruments
        b. The d'Arsonval movement
        c. DC ammeters and shunts
        d. DC voltmeters
        e. Meter sensitivity
        f. Galvanometers
        g. Ohmmeters
    2. The DC electric motor
B. Laboratory projects
    1. Galvanometers, ammeters, and voltmeters
    2. The potentiometer

IX. Alternating Current Measurements

A. Units of instruction
    1. Generation of alternating current
        a. AC generators
        b. Commutators
    2. Phasors and phase angle
    3. Average and RMS values of alternating current and voltage
    4. Inductive reactance
    5. Capacitive reactance
    6. Impedance
    7. AC motors
B. Laboratory projects
    1. AC current and voltage measurements
    2. Frequency measurements—the oscilloscope

X. Light

A. Units of instruction
    1. Geometrical optics
        a. Reflection
        b. Refraction
        c. Lenses
    2. Physical optics
        a. Diffraction
        b. Polarization
B. Laboratory projects
    Plane surface reflection and refraction

XI. The Relationship Between Thermal, Electrical and Mechanical Work, Energy and Power

A. Units of instruction
    1. Unit conversions
    2. Physical processes
        a. Photoelectric effect
        b. Thermoelectric effect
        c. Energy conversions in the refrigeration cycle
        d. First and second laws of thermodynamics
        e. Energy production by nuclear methods
        f. Conservation laws
B. Laboratory projects
    Mechanical equivalent of heat

Texts and References

BEISER. *Modern Technical Physics.*
BURBAN and SCHMITT. *Understanding Electricity and Electronics.*
HALLIDAY. *Physics for Students of Science and Engineering.*
HUNTEN. *Introduction to Electronics.*
JOSEPH AND OTHERS. *Physics for Engineering Technology.*
McCORMICK. *Fundamentals of University Physics.*
MILLER. *College Physics.*
POLLACK. *Applied Physics.*
SMITH AND COOPER. *Elements of Physics.*
WHITE AND OTHERS. *Practical Physics.*

Visual Aids

The following films are all available from the Visual Aids Service, Division of University Extension, University of Illinois. They are all 16 mm., sound and are described further in the '71-'74 "Science Films" catalog from the University of Illinois.

Atmosphere and Its Circulation, 10 min., black and white.
Atmospheric Pressure with the Magdeburg Experiment, 9 min., black and white.
Basic Electricity as Applied to Electronic Control Systems, 20 min., color.
Cathode Ray Oscilloscope, 20 min., black and white.
Demonstrating the Gas Laws, 21 min., color.
Electricity and Magnetism: Lessons 1, 2, 5, 8, 10, 12, 13, 17, 18, 23, of the Encyclopaedia Britannica series, 30 min., black and white.
Electromagnetic Induction, 14 min., black and white.
Electrostatic Charges and Forces, 14 min., black and white.
Fundamentals of AC and DC Generation, 19 min., color.
Gas Laws and Their Application, 17 min., black and white.
The Kinetic Theory of Matter, 13 min., color.
Laws of Gases, 11 min., black and white.
Lenses, 10 min., black and white.
Magnetism, 14 min., black and white.
Nature of Heat, 10 min., black and white.

Ohm's Law, 19 min., black and white.
Rotating Magnetic Fields, 13 min., black and white.
Spectrograph, The, 20 min., color.
Thermodynamics, 10 min., black and white.

BIOLOGY

Hours Per Week

Class, 3; Laboratory, 4

Description

This course deals with the basic concepts of environmental biology and the study of living organisms as functional units. The principles involved in the interrelationship of the various systems and the overall functioning of the organism are studied. Concepts of cellular respiration, energy relationships, nutrition, photosynthesis, reproduction and physical and chemical components of living things are discussed. In addition, such concepts as energy flow, ecological niche, environmental resistance and various factors contributing to the upset of such balance are considered.

Major Divisions

	Hours	
	Class	*Laboratory*
I. Nature and Scope of Science	1	0
II. Cellular Structure and Function	3	4
III. Energy in Living Systems	4	4
IV. Photosynthesis	3	8
V. Cellular Metabolism	3	8
VI Reproduction	5	4
VII. Nature of the Ecosystem	3	4
VIII. Major Biomes	2	0
IX. Energy Flow in an Ecosystem	2	4
X. Biogeochemical Cycles	3	4
XI. Interaction in an Ecosystem	4	4
XII. Evolution and Populations	6	4
XIII. Ecology of Populations	3	4
XIV. Changes in an Ecosystem	1	4
XV. Upsetting the Balance	1	4
XVI. Endangered Natural Communities	2	4
XVII. Human Populations	2	0
Total	48	64

I. Nature and Scope of Science

A. Units of instruction
   1. The Scientific Method
      a. Observations
      b. Hypothesis
      c. Experiment
      d. Conclusion
      e. Theory
      f. Law
   2. Science and philosophy
B. Laboratory projects: none

II. Cellular Structure and Function

A. Units of instruction
   1. Diversity and similarity of cells
      a. Cell size
      b. Surface area and environmental interaction
      c. Viruses
   2. Cellular organelles and their functions
      a. Nucleus
      b. Mitochondria
      c. Ribosome
      d. Cell membrane
      e. Endoplasmic reticulum
      f. Cytoplasm
      g. Chloroplast
      h. Lucoplasts
      i. Golgi bodies
      j. Lysosomes
   3. Multicellular organization and specialization
B. Laboratory projects
   1. General survey of cell types and subcellular organelles. (Cork, elodea, onion skin, potato tubes, onion root tips, root hairs and stained slides may be used).
   2. Use paper chromatography techniques to separate subcellular components.

III. Energy in Living Systems

A. Units of instruction
   1. Forms of energy
      a. Kinetic
      b. Potential
      c. Chemical
      d. Light
      e. Heat
      f. Mechanical
      g. Electrical
   2. Transformation of energy and energy levels
   3. Enzymes and catalysis

4. Oxidation and reduction
5. High energy molecules
   a. ATP
   b. $NADH_2$
   c. $FADH_2$

B. Laboratory projects
   1. Use of a calorimeter to determine amount of energy in various living things.
   2. Determine the source of energy in specific organisms and the effects of a break in the flow of energy from its source.

IV. Photosynthesis

A. Units of instruction
   1. History
   2. Potential
   3. Absorption of light and pigment system
   4. Light reaction
   5. Dark reaction
   6. Summation – rate comparison
   7. Effects of air pollutants on photosynthetic rates
      a. Decrease in light intensity
      b. CO_2 levels
      c. Chemical inhibitors

B. Laboratory projects
   1. Particulate air pollutants often settle on the surfaces of leaves, which could interfere with the photosynthetic process. Apply an artificially induced covering of dust to a plant and measure the rate of photosynthesis. Compare with an identical plant not treated with dust.
   2. Study absorption data of various plant pigments with the aid of a spectrophotometer.

V. Cellular Metabolism

A. Units of instruction
   1. Anaerobic respiration
      a. Ethanol formation (fermentation)
      b. Lactic acid formation
   2. Aerobic respiration
      a. Glycolysis
      b. Krebs cycle
      c. Terminal electron transport system

B. Laboratory projects
   1. Demonstrate fermentation.
   2. Test various foods with Benedict's solution and iodine.
   3. Demonstrate the release of CO_2 during respiration.
   4. Activity of various enzymes on foods.
   5. Demonstrate the liberation of CO_2, consumption of O_2 and heat release.

VI. Reproduction

A. Units of instruction
   1. Role of the nucleus
      a. Chromosome
      b. Diploid and haploid number
   2. Mitosis
   3. Meiosis
   4. Life cycles
   5. Mendelian genetics
      a. Monohybrid crosses
      b. Dihybrid crosses
   6. Mutations
      a. Chemical mutagens in polluted air
      b. Radiation
      c. Other mutagenic agents
      d. X-rays
      e. Chemical mutagens
      f. Ultra violet radiation
      g. Spontaneous mutation rates
      h. Increase of mutation and its effect on the gene pool

B. Laboratory projects
   1. Mitotic figures (prepared slides)
   2. Meiotic figures (prepared slides)
   3. Trace life cycles of various organisms

VII. Nature of the Ecosystem

A. Units of instruction
   1. Soil types
      a. Sand
      b. Loam
      c. Silt
      d. Clay
   2. Solar radiation
      a. Visible light
      b. Wavelengths
      c. Usable energy
      d. Efficiency in conversion at each trophic level
   3. Complex interrelationships
      a. Solar radiation
      b. Plants
      c. Herbivores
      d. Carnivores
      e. Decomposers
      f. Nutrient pool

B. Laboratory projects
   1. Make a field trip to an area to deter-

mine general physical and biological characteristics.
2. Collect plants, animals, soil, water, etc., for further study in the laboratory.

VIII. Major Biomes

A. Units of instruction
1. Tundra
2. Taiga
3. Deciduous forest
4. Temperate grassland
5. Chaparral
6. Desert
7. Tropical rain forest, deciduous forest, scrub forest and savanna
8. Mountains

B. Laboratory projects: none

IX. Energy Flow in an Ecosystem

A. Units of instruction
1. First law of thermodynamics
2. Second law of thermodynamics
3. Energy fixation by autotrophs
a. Photosynthesis
b. Efficiency in production
4. Trophic levels and energy
a. Primary consumer (herbivores)
b. Secondary consumers (carnivores)
c. Tertiary consumers (secondary carnivores)
d. Decomposers
e. Omnivores and complex systems

B. Laboratory projects
1. Seal a small snail in a test tube and vary the conditions (with soil; with plants; etc.) Determine how long it can survive.
2. Study a food web of the organisms in a very small area.

X. Biogeochemical Cycles

A. Units of instruction
1. Water
2. Nitrogen
3. O_2 - CO_2
4. Sedimentary nutrients
5. Carbon
6. Nutrient budgets and the ecosystem

B. Laboratory projects
1. Make field trips to observe soil types, erosion, watersheds, and measurement of rainfall.
2. Determine CO_2 utilization by plants or CO_2 production in a small enclosed jar filled with a few plants and animals.

XI. Interaction in an Ecosystem

A. Units of instruction
1. Predation
a. Natural defenses
b. Food supply
c. Value of predation
2. Parasitism
a. Parasite host relationship
b. Epidemics
3. Mutualism
4. Interspecific competition

B. Laboratory projects
1. Study a small pond and look for interrelationships between life forms.
2. Prepare a balanced sealed ecosystem in the laboratory.

XII. Evolution and Populations

A. Units of instruction
1. Genetic makeup of populations
a. Genetic variations
b. Gene pools
c. Natural selection
d. Genetic drift
2. Adaptation
a. Protective coloration
b. Mimicry
c. Warning signals
d. Physiological and biochemical adaptations
3. Species and speciation
a. Units of population
b. Speciation
c. Isolating mechanisms

B. Laboratory project

Expose several different kinds of lichens to known concentrations of common air pollutants such as carbon monoxide, sulfur dioxide and hydrocarbons. Determine the relation between specific pollutant concentration and the effects on populations of lichens.

XIII. Ecology of Populations

A. Units of instruction
1. Population growth
2. Equilibrium of populations
a. Mortality rate
b. Food supply
c. Reproductive success

d. Ecological niche

B. Laboratory projects
   1. Determine predator-prey relations in field situations
   2. Look for parasite-host relationships
   3. Plot epidemics of various diseases

XIV. Changes in an Ecosystem

A. Units of instruction
   1. Ecological succession
   2. Climax ecosystem

B. Laboratory projects
   1. Determine what types of changes are natural in an ecosystem.
   2. Field work—what stage of change is a particular area undergoing.

XV. Upsetting the Balance

A. Units of instruction
   1. Pollution
   2. Overpopulation

B. Laboratory projects
   1. Determine the median lethal dose (MLD) of several common air pollutants on groups of mice, rats or hamsters.
   2. Estimate the effects of various air pollutants on the plants in a selected industrial area.

XVI. Endangered Natural Communities

A. Units of instruction
   1. Extinction
   2. Endangered species
   3. Regulations for preservation

B. Laboratory projects
   1. Determine what populations or ecosystems are in danger. Determine the various factors involved.
   2. Help save a local endangered species or natural community.

XVII. Human Populations

A. Units of instruction
   1. Optimum populations
   2. Birth control
   3. Food production
   4. Limits of the earth

B. Laboratory projects: none

Texts and References

BOUGHEY. *Ecology of Populations.*
CURTIS. *Biology.*
HARDIN. *Population, Evolution and Birth Control—A Collage of Controversial Ideas.*
KEETON. *Biological Sciences.*
KORMONDY. *Concepts of Ecology.*
LERNER. *Heredity, Evolution and Society.*

Visual Aids (Films are color, 16 mm.)

Harper and Row, Publishers, Inc., College Department, New York, N.Y. 10016.

Amoeba Enucleation, #04-77778 Cartridge; #04-77786 Reel; 3 min., 5 sec.

Cytoplasmic Motility, #04-75152 Cartridge; #04-75160 Reel; 3 min. 10 sec.

The Dividing Cell, #81-5936/1, 3 min. 40 sec.

Evolution of Protective Coloration, #04-78156 Cartridge; #04-78164 Reel; 3 min. 45 sec.

Darwin's Voyage, set of 6 color film loops in super 8 cartridges.
(*The Voyage of the Beagle,* 81-7494/1)
(*Brazil, Tropical Rain Forest,* 81-7502/1)
(*The Galapagos: Geological Evidence,* 81-7510/1)
(*The Galapagos: Darwin's Finches,* 81-7528/1)
(*The Galapagos: Iguanas,* 81-7536/1)
(*The Galapagos: Tortoises,* 81-7544/1)

Plankton: Food Webs and Feeding Relationships, #81-6850/1, 3 min. 40 sec.

Prey-Predator Interactions—The Moth, the Wasp, and the Mite, #04-78735 Cartridge; #04-78743 Reel; 3 min. 30 sec.

Pollution, two loops, Part 1: The Problem, #04-78651 Cartridge; #04-78669 Reel; Part II: Is There a Solution?, #04-78933 Cartridge; #04-78941 Reel; 3 min. 40 sec. each.

Biomes, set of 4.
(*World Distribution of Biomes,* #04-79071 Cartridge; #04-79089 Reel)
(*Dry Season Tropical Forest,* #04-79055 Cartridge; #04-78008 Reel)
(*Tropical Wet Forest,* #04-79055 Cartridge; #04-79063 Reel)
(*Grasslands,* #04-79030 Cartridge; #04-79048 Reel)

McGraw-Hill Book Company, Text-Film Division, 330 West 42nd Street, New York, N.Y. 10036.

Mystery of Life, #RO-76, 25 min.
Riddle of Heredity, #RO-87, 30 min.
Standing Room Only, #RO-99, 25 min.
The Winners, #RO-99, 30 min.
Survival in the Sea, #RO-90, 30 min.

AUXILIARY OR SUPPORTING TECHNICAL COURSES

METEOROLOGY

Hours Per Week

Class, 1; Laboratory, 3

Description

The movement of air masses is directly responsible for the dispersion of air pollutants in the atmosphere. Therefore an understanding of some of the basic meteorological fundamentals is essential to the air pollution technician. A study of some meteorological measurements leads to a consideration of the variables involved in describing weather systems.

Topics including global convection currents, rotational effects, moisture content, air velocity and turbulence are studied as contributing factors to the phenomenon known as "weather". From a consideration of weather on a global scale, the student is introduced to local air movements, fronts and lapse rates as they affect air pollutant dispersion. Topographic features are viewed as factors influencing local weather conditions. Weather forecasting is presented as a useful tool in predicting the occurrence of adverse air pollution conditions. Laboratory projects emphasize practical experience in operating various types of meteorological equipment and instruments. A field trip to a meteorological station is included to provide first hand observations of commonly used equipment and techniques in weather forecasting and reporting.

Major Divisions

		Hours	
		Class	*Laboratory*
I.	Meteorological Measurements	1	6
II.	Laws Governing Atmospheric Variables	2	6
III.	Solar Radiation and the Global Heat Balance	2	3
IV.	Lapse Rates and Stability	2	3
V.	Evaporation and Condensation	1	3
VI.	General and Secondary Circulation and Local Air Movements	2	6
VII.	Air Masses and Fronts	2	6
VIII.	Weather Analysis and Forecasting	1	6
IX.	Turbulence	1	6
X.	Diffusion from a Continuous Source	2	3
	Total	16	48

I. Meteorological Measurements

- A. Units of instruction
  - 1. Primary meteorological measurements
    - a. Wind direction
    - b. Wind speed
    - c. Wind turbulence
  - 2. Secondary meteorological measurements
    - a. Temperature
    - b. Visibility and turbidity
    - c. Humidity
    - d. Precipitation
    - e. Solar radiation
  - 3. Instrument siting, mounting, and protection
    - a. Principles of instrument siting
    - b. Fixed instruments
    - c. Movable instruments
  - 4. Instrument requirements
    - a. Minimum instrumentation
      - (1) Recording wind vane
      - (2) Totalizing cup anemometer
      - (3) Towers
    - b. Intermediate instrumentation
      - (1) Adequate towers
      - (2) Wind vanes
      - (3) Totalizing cup anemometers
      - (4) Shielded temperature sensors
      - (5) Gust accelerometer or bivane
      - (6) Rain gages
    - c. Maximum instrumentation
      - (1) Instrumentation mentioned above
      - (2) Wiresondes
      - (3) Rocketsondes
      - (4) Rawinsondes
      - (5) Aircraft observations
      - (6) Mobile meteorological stations
      - (7) Meteorological data loggers
- B. Laboratory projects
  - 1. Study several of the following instruments paying close attention to siting, mounting, and mobility:

a. Anemometer
b. Bivane
c. Sling psychrometer
d. Maximum minimum thermometer
e. Rain gage
f. Solarimeter
2. Maintain wind speed and direction readings, precipitation, minimum and maximum temperature readings, and humidity readings for one week. Compare these data with similar information furnished by a nearby weather station.

II. Laws Governing Atmospheric Variables

A. Units of instruction
1. Gas laws
a. Variables of state
b. Charles' Law
c. Boyle's Law
d. Dalton's Rule
2. Newton's 2nd Law
a. Hydrostatics
b. Wind and pressure
3. Humidity and water vapor
a. Wet and dry bulb temperatures
b. Humidity ratio
c. Relative humidity
d. Thermodynamic dew point temperature
e. Psychrometric charts
f. Transport properties of moist air
B. Laboratory projects
1. Measure the local wet and dry bulb temperatures using a sling psychrometer.
2. Determine the relative humidity of the air using wet and dry bulb temperature readings and a psychrometric chart. Compare with humidities obtained with a thermohumidigraph.
3. Determine the dew point of the air.
4. Examine the properties and interrelationships displayed on a psychrometric chart. Construct a isopleth for each of the principal quantities.

III. Solar Radiation and the Global Heat Balance

A. Units of instruction
1. Solar radiation
a. The sun
b. The "greenhouse" effect
c. The solar constant
2. The global heat balance
a. The earth atmosphere system
(1) Ground
(2) Troposphere
(3) Stratosphere
(4) Space
b. Variables affecting the heat balance
(1) Temperature
(2) Pressure
(3) Properties of heat-absorbing and heat emitting gases
(4) Cloudiness
c. The mean annual heat balance
(1) Short-wave radiation
(a) Sources
(b) Absorbing media
(2) Long-wave radiation
(3) Non radiative effects
(a) Evaporation
(b) Turbulence
(c) Ocean
B. Laboratory projects
1. Using *Climatological Data*, compare the solar radiation reaching the earth for various latitudes and longitudes covering the United States.
2. Using rawinsonde data (*Climatological Data*), from a nearby station, make a temperature-altitude plot for a winter month and a summer month. Compare the curves.

IV. Lapse Rates and Stability

A. Units of instruction
1. Lapse rates
a. Definition
b. Strong lapse rate
c. Dry adiabatic lapse rate
d. Weak lapse rate
e. Isothermal
f. Inversion
2. Stability and instability
a. Absolutely stable
b. Saturated neutral
c. Conditionally unstable
d. Dry neutral
e. Absolutely unstable
B. Laboratory projects
1. Using the data from the previous laboratory project, identify the lapse rates indicated by the data and discuss the relative stability of the atmospheres represented by the data.
2. Discuss how the concentrations of pollutants from a source might be affected by changes in atmospheric stability.
3. Examine the weather conditions which prevailed during major air pollution disasters.

V. Evaporation and Condensation

A. Units of instruction
1. Evaporation from bodies of water
a. Effect of wind speed
b. Effect of atmospheric moisture content
2. Condensation
a. Clouds
(1) Formation
(2) Classification
(3) Man made clouds
b. Precipitation
(1) Precipitation processes
(2) Precipitation types

B. Laboratory projects
1. Restudy the various pieces of equipment available for measuring precipitation. Compare on the basis of cost, maintenance, and accuracy.
2. Locate several sources of precipitation data.
a. Local weather stations
b. Airports
c. Agricultural facilities
d. Radio and TV stations
e. Fire weather service stations
f. Climatological data
g. Daily weather map

VI. General and Secondary Circulation and Local air movements

A. Units of instruction
1. Factors influencing general circulation
a. The global heat balance
b. The rotation of the earth
2. Palmen's Model of general circulation
a. Polar tropopause
b. Polar front jet
c. Polar front
d. Tropical tropopause
e. Cyclones and anticyclones
3. Winds
a. Definition
b. Factors affecting winds
(1) Coriolis force
(2) Pressure gradient force
(3) Friction force
c. Sources of wind velocity and direction data
(1) Weather maps
(2) Wind roses
(3) Other sources
(4) Influence of topography on air movement
(a) Valley effects
(b) Shoreline winds
(c) Urban effect

B. Laboratory projects
1. Make a field trip to a weather station. Identify the instrumentation used there, paying particular attention to siting, mountings, and methods of data reduction.
2. For a set of wind direction and speed occurrences, remove the bias for a wind rose and distribute the calms. Plot the resulting wind rose.
3. Study examples of the following specialized wind roses:
a. Precipitation wind rose
b. Stability wind rose
c. Pollution wind rose
4. Study the symbols used on weather maps.
5. Compare meteorological data for a large city with data for some nearby rural area. Discuss how each of the following meteorologic parameters might be affected by a city.
a. Temperature ("heat-island" effect)
b. Humidity
c. Precipitation
d. Snow
e. Cloudiness
f. Wind
g. Radiation

VII. Air Masses and Fronts

A. Units of instruction
1. Air masses
a. Maritime air masses
b. Continental air masses
c. Arctic origin
d. Polar origin
e. Tropical origin
2. Fronts
a. Formation of frontal systems
b. Polar and equatorial fronts
c. Cold fronts
(1) Lifting stable air
(2) Lifting unstable air
(3) Barometer response
d. Warm fronts
(1) Advancing warm air
(2) Stable warm air
(3) Unstable warm air
(4) Barometer response
e. Stationary fronts
f. Warm fronts
g. Occluded fronts
h. Fronts as shown on weather map

B. Laboratory projects
1. Make models of several types of front

al weather.
2. Diagram several stages in the life history of a frontal low.
3. Maintain barometer reading when a frontal system passes.
4. Obtain weather maps for several days and trace the movement of high and low pressure cells.

VIII. Weather Analysis and Forecasting

A. Units of instruction
  1. U. S. Weather Bureau services
    a. 24-hour detailed forecasts
    b. General 5-day forecasts
    c. 30-day general outlook
    d. Aviation forecasts
    e. Warnings
  2. Forecasting
    a. Weather lore
    b. Data collection
    c. Weather maps and charts
    d. Numerical forecasts
    e. The forecast reliability
B. Laboratory projects
  1. Make a 6-12 hour forecast based on the use of the persistence and a single weather map.
  2. Compare several daily weather maps and make a forecast for the next day based on this comparison.
  3. Make a forecast based on "weather signs," barometer, and weathervane readings.

IX. Turbulence

A. Units of instruction
  1. Variability of the wind
    a. Mechanical turbulence
    b. Thermal turbulence
  2. Turbulence and Atmospheric Stability
    a. Indirect measurement of turbulence
    b. Strong lapse rates
    c. Inversion conditions
B. Laboratory projects
  1. Study several methods of measuring wind turbulence
    a. Rapid response wind instruments
      (1) Wind vanes
      (2) Bivanes
      (3) Anemometers
      (4) Hot-wire anemometers
    b. Indirect measurement of wind turbulence
      (1) Temperature lapse rates
      (2) Radiation
      (3) Smoke photography
  2. Monitor wind speed and direction for several days and compare degree of turbulence with turbulence indicated by measured lapse rates.

X. Diffusion From a Continuous Source

A. Units of instruction
  1. Estimating pollutant concentrations from area sources
    a. Assumptions
      (1) Approximation of source by rectangular area
      (2) Presence of inversion layer
      (3) Complete volumetric mixing under inversion layer
    b. Equation for pollutant concentration
  2. Estimation of ground level pollutant concentrations resulting from conical stack plumes
    a. Assumptions
      (1) Conical plume
      (2) Angle from source
    b. Equation for maximum ground level concentration (Bosanquet-Pearson Equation)
    c. Equation to design stack for desired maximum ground concentration (Davidson-Bryant Equation)
  3. Influence of lapse rate upon stack effluents
    a. L[illegible]ping
    b. Coning
    c. Fanning
    d. Lofting
    e. Fumigation
    f. Trapping
B. Laboratory projects
  1. Work sample problems illustrating use of equations for estimating ground level concentrations of pollutants.
  2. Illustrate stack plumes for various lapse rate configurations.

Texts and References

BYERS. *General Meteorology.*
FENSTERST[illegible] AND FANKHAUSER. *Thanksgiving 1966 Air Pollution Episode in the Eastern United States.*
LEHR AND OTHERS. *Weather.*
PETTERSSEN. *Introduction to Meteorology.*
STERN. *Air Pollution.* Vol. 1 and Vol. 2.
U.S. DEPARTMENT OF HEALTH, EDUCATION AND WELFARE. *Tall Stacks, Various Atmospheric Phenomena and Related Aspects.*

WILLETT AND SANDERS, *Descriptive Meteorolgy*
WORLD HEALTH ORGANIZATION, *Air Pollution*
Journal of Applied Meteorology
Journal of Meteorology
Weather

Visual Aids

(Films are color)

Harper and Row Publishers, Inc., New York, N.Y. 10016.
Climatology: *Some Causal Factors*. 8 mm., (Super), 4 min., sound.

U. S. Environmental Protection Agency, Technical Audio-Visual Branch, Research Triangle Park, N.C. 27711.
Adiabatic Processes, MA11, 16 mm., 13 min., sound.
Existing Temperature Distribution, MA10, 16 mm., 13 min., sound.
Origins of Weather, MA61, 16 mm., 13 min., sound.
Smoke Diffusion Studies, MA18, 16 mm., 21 min., silent.
Stability and the Weather, MA13, 16 mm., 8 min., sound.
Thermal Convection, MA12, 16 mm., 10 min., sound.

INTRODUCTION TO WASTEWATER TECHNOLOGY

Hours Per Week

Class, 2; Laboratory, 3

Course Description

This course provides the student with a broad overview to the field of wastewater: its sources, treatment and effects on receiving bodies of water. Topics range from engineering considerations to wastewater hydraulics to the complex interrelationships existing in biological systems. Discussion of some of the basic physical, chemical and biological principles provides an introduction to various treatment processes. The treatment plant itself is considered as a complex instrument designed to perform a specific job. The ultimate value of the treatment process is then judged in terms of the effects the effluent has on receiving bodies of water. Laboratory exercises are selected to demonstrate various characteristics of wastewater from its origin through treatment to final discharge.

Major Divisions

	Hours Class	Laboratory
I. Wastewater	2	3
II. Wastewater Collection	2	3
III. Industrial Wastewaters	1	6
IV. Physical Aspects of Wastewater	3	3
V. Chemical Properties of Wastewater	5	9
VI. Biological Aspects of Wastewater	5	9
VII. Methods of Treatment	6	0
VIII. The Treatment Plant	2	6
IX. Effect of Wastes on Receiving Waters	4	9
Total	32	48

Wastewaters

A. Units of Instruction
   1. Necessity of treatment
      a. Protect public health
      b. Prevent nuisances
      c. Protect natural resources
      d. Recover resources
      e. Comply with regulatory agencies
   2. Early leaders in treatment
      a. Edwin Chadwick
      b. Thomas Hawksley
      c. Robert Rawlinson
      d. John Roe
      e. John Snow
      f. Edward Frankland
      g. Lemuel Shattuck
      g. Julian Adams
      i. Allen Hazen
      j. William Sedgwick
      k. Earle B. Phelps
   3. Quantities
      a. Population characteristics
      b. Flow per capita
      c. Flow patterns
      d. Infiltration
      e. Industrial
      f. Storm water

B. Laboratory Projects
   1. Visit laboratory section of local health department.
   2. Predict population growth of typical city by graphical projection, showing arithmetical, geometric, and incremental increase and the population census ratio.
   3. Determine yield of watershed by rainfall runoff relationship.

II. Wastewater Collection

A. Units of instruction
   1. Terminology

    - a. Sewerage
    - b. Sewer
    - c. Sewage types
    - d. System types
  - 2. Transportation
    - a. Gravity flow
    - b. Pressure mains
    - c. Pumping stations
    - d. Related equipment
  - 3. Design of collection systems
    - a. Population
    - b. Flow formulas
    - c. Nomographs
    - d. Map construction
    - e. Profiles
    - f. Construction materials
    - g. Construction procedures
- B. Laboratory Projects
  - 1. Using data from a municipal sewage treatment plant, plot minimum, maximum and average monthly flows for one year.
  - 2. Plot minimum, maximum and average organic loading by months for one year.
  - 3. Determine the effect of rainfall on flow variations.
  - 4. From sewage plant equipment sizes, determine average detention time vs. % suspended solids removed.

III. Industrial Wastewaters

- A. Units of Instruction
  - 1. Nature of wastes
    - a. Inorganic
    - b. Organic
    - c. Mixtures
    - d. Miscellaneous characteristics
  - 2. Treatment of concentrated effluents
    - a. Centrifugation
    - b. Filtration
    - c. Evaporation
    - d. Concentration
      - (1) Settling pond
      - (2) Thickener
      - (3) Decanter
    - e. Distillation
    - f. Liquid liquid extraction
  - 3. Treatment of dilute wastewater
    - a. General considerations
      - (1) Flow data
      - (2) Physical properties
      - (3) Chemical composition
      - (4) Biological effects
    - b. Treatment requirements
    - c. Neutralization
    - d. Liquid solids separation
    - e. Biological oxidation
    - f. Removal of specific components
    - g. Plant control programs
    - h. Economic considerations
  - 4. Activated carbon adsorption
    - a. Liquid phase systems
    - b. Selection of adsorbents
    - c. Reclamation of wastewater effluents
    - d. Byproduct recovery
  - 5. Ion exchange systems
    - a. Resins
    - b. Equipment and processes
    - c. Cost calculations
    - d. Acid purification
    - e. Continuous ion exchange
    - f. Ion exclusion
- B. Laboratory Projects
  - 1. Perform jar tests on samples of industrial wastewater using different treatment chemicals to determine which is most efficient.
  - 2. Compare recommended treatment with treatment actually used.
  - 3. Observe and identify the principles and methods used in an industrial wastewater treatment process in a local plant.

IV. Physical Aspects of Wastewater

- A. Units of Instruction
  - 1. Temperature
    - a. Range
    - b. Effect on decomposition rate
    - c. Effect on dissolved oxygen
  - 2. Turbidity
    - a. Origin
      - (1) Organic
      - (2) Inorganic
    - b. Significance
      - (1) Aesthetic
      - (2) Treatment methods
      - (3) Sterilization
    - c. Methods of determination
      - (1) Turbidimeter
      - (2) Bottle standards
      - (3) Color discs
  - 3. Color
    - a. Significance
    - b. Methods of determination
      - (1) Standard color solutions
      - (2) Color discs
  - 4. Solids
    - a. Types
      - (1) Suspended
      - (2) Settleable

      - (3) Dissolved
      - (4) Volatile
      - (5) Total
    - b. Methods of determination
      - (1) Evaporation
      - (2) Filtration
      - (3) Sedimentation
- B. Laboratory Projects
  - 1. For a sample of wastewater, make temperature, turbidity and color tests.
  - 2. Using an Imhoff cone, test a wastewater sample for settleable solids.
  - 3. Make determinations of volatile, suspended, dissolved and total solids.

V. Chemical Properties of Wastewater

- A. Units of Instruction
  - 1. Dissolved oxygen
    - a. Significance
    - b. Sampling
    - c. Testing methods
      - (1) Winkler
      - (2) Rideal-Stewart
      - (3) Alkali-hypochlorite
      - (4) Instrumental methods
    - d. Calculation procedures
      - (1) Hatfield formula
      - (2) Truesdale formula
      - (3) Saturation formula
  - 2. Chemical oxygen demand
    - a. Significance
    - b. Testing factors
      - (1) Sample size
      - (2) Temperature
      - (3) Reagents
      - (4) Titration
    - c. Comparison with BOD
  - 3. Biochemical oxygen demand
    - a. Significance
      - (1) Definition
      - (2) Types of demand
      - (3) Stabilization time
      - (4) Ultimate BOD
    - b. Determination
      - (1) Dilution water
      - (2) Dilution series
      - (3) Incubation
      - (4) Oxygen depletion limits
      - (5) Calculation
    - c. Predictive methods
      - (1) Streeter-Phelps equation
      - (2) Rapid ratio method
      - (3) Thomas' slope method
      - (4) Moore's moment method
      - (5) Tsivoglov's method
  - 4. Hydrogen-ion concentration (pH)
    - a. Theory
      - (1) Ionization constant
      - (2) Ion types
    - b. Measurement
      - (1) Colorimetric methods
      - (2) Instrumental methods
    - c. Significance
      - (1) Acidity-alkalinity concepts
      - (2) Effects on biological processes
  - 5. Alkalinity
    - a. Significance
    - b. Methods of determination
      - (1) Titration
      - (2) Instrumental methods
      - (3) Indicators
    - c. Expression of results
      - (1) Hydroxide
      - (2) Carbonate
      - (3) Bicarbonate
      - (4) Total
  - 6. Hardness
    - a. General
      - (1) Definition
      - (2) Occurrence
      - (3) Significance
    - b. Sources
      - (1) Calcium
      - (2) Magnesium
      - (3) Strontium
      - (4) Iron
      - (5) Manganese
    - c. Methods of determination
      - (1) Soap
      - (2) E.D.T.A.
    - d. Types
      - (1) Carbonate
      - (2) Noncarbonate
  - 7. Other significant chemicals
    - a. Chlorides
      - (1) Occurrence
      - (2) Significance
      - (3) Methods of determination
    - b. Nitrogen
    - c. Phosphates
    - d. Fluorides
    - e. Iron
    - f. Volatile acids
    - g. Grease
    - h. Toxic metals
- B. Laboratory projects
  - 1. Determine dissolved oxygen of a wastewater sample by a chemical and an instrumental method and compare results
  - 2. Determine the chemical oxygen demand of a wastewater sample
  - 3. Determine the B.O.D. of a wastewater sample

4. Test the pH, alkalinity and hardness of a water sample and compare with a sample of wastewater

VI. Biological Aspects of Wastewater

A. Units of Instruction
  1. Cellular biology
    a. Sizes, shapes and types
    b. Cell parts
      (1) Animal
      (2) Plant
    c. Reproduction
      (1) Mitosis
      (2) Meiosis
    d. Cell metabolism
      (1) Anabolism
      (2) Catabolism
      (3) Aerobic
      (4) Anaerobic
  2. Bacteria
    a. Characteristics
    b. Major types
    c. Effect on decomposition of organic matter
  3. Fungi
    a. Characteristics
      (1) Reproduction
      (2) Branching
      (3) Aerobic
    b. Major types
      (1) Slime
      (2) Molds
      (3) Yeasts
    c. Identification
    d. Effect on wastewater treatment
  4. Algae
    a. Characteristics
    b. Major types
      (1) Green
      (2) Blue-green
      (3) Yellow-green
      (4) Euglenas
      (5) Dinoflagellates
    c. Identification
    d. Effect on water systems
      (1) Taste
      (2) Odor
      (3) Filter operation
  5. Protozoa
    a. Characteristics
    b. Major types
      (1) Mastigophora
      (2) Ciliata
      (3) Sarcodina
      (4) Sporozoa
    c. Identification
    d. Effect on public health
      (1) Decomposition of organic wastes
      (2) Relationship to disease
  6. Higher life forms
    a. Major types
      (1) Rotifers
      (2) Crustacea
      (3) Worms
      (4) Larvae
    b. Identification
    c. Effect on public health
B. Laboratory projects
  1. Examine samples of water under a microscope and identify major types of micro-organisms.
  2. Prepare a gram stain of a known culture.
  3. Prepare a bacterial culture on nutrient media and determine the plate count.
  4. Prepare a multiple-tube fermentation series and determine MPN.
  5. Perform a membrane—filter test.

VII. Methods of Treatment

A. Units of Instruction
  1. Pre-treatment
    a. Grit removal
    b. Grease removal
    c. Screening
    d. Odor control
    e. Aeration
    f. Grinding
    g. Measuring
  2. Primary treatment
    a. Sedimentation
    b. Sludge disposal
      (1) Anaerobic digestion
      (2) Aerobic digestion
      (3) Dewatering
  3. Secondary treatment
    a. Purposes
    b. Filtration process
      (1) Intermittent sand filter
      (2) Standard rate filter
      (3) High rate filter
    c. Activated sludge process
      (1) Conventional
      (2) Contact stabilization
      (3) Extended aeration
    d. Secondary sedimentation
      (1) Clarification
      (2) Thickening
  4. Tertiary treatment
    a. Purposes
      (1) Additional organic removal
      (2) Removal of nutrients

(3) Disinfection
b. Experimental methods
(1) Very fine screens
(2) Rapid sand filter
(3) Carbon adsorption
5. Other treatment methods
a. Septic tank
(1) Oldest treatment device
(2) Anaerobic
b. Imhoff tank
(1) Primary sedimentation device
(2) Usage largely discontinued
c. Lagoons
(1) Aerobic
(2) Anaerobic
B. Laboratory projects (none)

VIII. The Treatment Plant

A. Units of instruction
1. Physical facilities
a. Appearance
b. Flow patterns
c. Location of units
d. Size of units
2. Hydraulic layout of plant
a. Pipe sizes
(1) Flow
(2) Head loss
b. Recirculation
c. Pump study
(1) Flow
(2) Head
(3) Horsepower
3. Laboratory
a. Equipment
b. Routine testing requirements
c. Records and reports
4. Maintenance
a. Purposes
b. Lubrication
c. Protective coatings
d. Safety inspections
B. Laboratory projects
1. Prepare a flow diagram for a municipal wastewater plant showing flow rates and treatment processes.
2. Calculate the hydraulic head loss in the plant.
3. Determine percent of design capacity at which the plant normally operates.
4. Visit the plant laboratory and list the frequency and kinds of tests made.

IX. Effect of Wastes on Receiving Waters

A. Units of Instruction
1. Zones of pollution
a. Degradation
b. Decomposition
c. Recovery
2. Methods of recovery
a. Wind action
b. Biological organisms
c. Shallow vs. deep water
d. Indices of self purification
3. Biological indicators
a. Worms
b. Fungi
c. Protozoa
d. Fish kills
4. Bottom deposits
a. Oxygen demand
b. Oxygen penetration
c. Rising problems
5. Industrial Wastes
a. Oxygen consuming wastes
b. Colored wastes
c. Toxic wastes
d. Obstructing wastes
e. Acid and alkaline wastes
f. Thermal pollution considerations
B. Laboratory Projects
1. Perform a bioassay test for a selected toxic chemical and determine MLD.
2. Perform dissolved oxygen tests at wastewater outfall, upstream and several points downstream and compare results.
3. Compare solids and dissolved oxygen content for the discharge of a waste water lagoon with the effluent from a municipal waste treatment plant.

Texts and References

AMERICAN PUBLIC HEALTH ASSOCIATION. *Standard Methods for the Examination of Water and Wastewater.*
ECKENFELDER AND O'CONNOR. *Biological Waste Treatment.*
FAIR AND GEYER. *Elements of Water Supply and Wastewater Disposal.*
HARDENBERGH AND RODIE. *Water Supply and Waste Disposal.*
HAWKES. *The Ecology of Wastewater Treatment.*
IMHOFF AND FAIR. *Sewage Treatment.*
KITTRELL. *A Practical Guide to Water Quality Studies of Streams.*
PELCZAR AND REID. *Microbiology.*
RICH. *Unit Processes of Sanitary Engineering.*
ROSS. *Industrial Waste Disposal.*

Visual Aids

U. S. Public Health Service, Audiovisual Facility, Atlanta, Ga. 30333.
Municipal Sewage Treatment Processes, M-6, 16 mm., 13 min., b/w, sound.
The Membrane Filter, F-386, 35 mm., 80 frames, color, sound, (12 in. recording, 12 min.)

The Water Famine, MIS 831, 16 mm., 26 min., b w, sound.
Trickling Filter Plants, 5 519, 35 mm., 94 frames, b w, sound (33 1 3 rpm recording, 9 min.)
Troubled Waters, MIS 867, 16 mm., 28 min., color, sound.

PRINCIPLES OF SOLID WASTE MANAGEMENT

Hours Per Week

Class, 2; Laboratory, 3

Course Description

The growing problems connected with the generation and disposal of solid wastes are considered in detail. The magnitude of the problem, sources, types and quantities of refuse are studied. Various kinds of collection and disposal systems and the strengths and weaknesses of each are examined in the light of optimum disposal practice. Laboratory exercises cover a broad range of experiences from detailed laboratory analyses to broad field investigations of various aspects of the solid waste problem.

Major Divisions

	Hours	
	Class	*Laboratory*
I. Introduction	4	6
II. Classification of Solid Wastes	3	9
III. Solid Waste Collection	4	6
IV. Reduction and Disposal Methods	15	9
V. Salvage Operations	3	9
VI. Management of Disposal Systems	3	9
Total	32	48

I. Introduction

A. Units of Instruction
1. Definition of solid waste
a. Useless materials
b. Unwanted materials
c. Unused materials
2. Magnitude of the problem
a. Population
(1) History
(2) Projections
(3) Density
b. Factors affecting quantities
(1) Climate
(2) Season
(3) Standard of living
(4) Geographic location
(5) Extent of industrialization
(6) Frequency of collection
c. Costs
(1) Collection
(2) Disposal
3. Necessity for disposal
a. Public health aspects
(1) Rat harborage
(2) Flies
(3) Mosquitoes
(4) Other disease-carrying vectors
b. Esthetics
c. Effect on property values
d. Nuisance effect
4. Legislation pertaining to solid waste
a. Federal
b. State
c. Local
(1) Responsibility for administration
(2) Collection practices
(3) Financial
(4) Penalties

B. Laboratory Projects
1. Select projects concerned with the generation or disposal of different types of solid wastes. These topics can be assigned on a small group or individual basis. The topic is examined and studied in detail and a written and/or oral report is presented to the entire class. Examples of projects or topics are as follows:
a. Highway litter—for a representative section of public highway collect all solid refuse, separate into standard categories and determine the percent composition. By extrapolation, estimate the total amount of highway litter for a given highway or highway system.
b. Study the feasibility and extent of recycling aluminum and glass containers. Investigate the economics involved with each method.
c. Obtain data on the generation and disposal of solid wastes from natural disasters.
d. Investigate the generation and dis

posal of solid wastes from spectator sporting events.

- e. Investigate the generation and disposal of solid wastes from the airline industry.

II. Classification of Solid Wastes

- A. Units of Instruction
  - 1. Origin
    - a. Domestic
    - b. Institutional
    - c. Commercial
    - d. Industrial
    - e. Street
    - f. Demolition
    - g. Construction
  - 2. Composition
    - a. Organic content
    - b. Inert content
    - c. Combustibility
    - d. Putrescibility
    - e. Moisture content
  - 3. Kinds
    - a. Garbage
      - (1) Wastes from food preparation
      - (2) Swill and slops
      - (3) Offal and market wastes
    - b. Rubbish
      - (1) Combustible
      - (2) Non combustible
    - c. Ashes
    - d. Street refuse
    - e. Dead animals
    - f. Abandoned vehicles
    - g. Industrial wastes
    - h. Building industry
      - (1) Construction
      - (2) Demolition
    - i. Special wastes
      - (1) Sewage treatment solids
      - (2) Radioactive wastes
      - (3) Explosive or hazardous wastes
      - (4) Pathological wastes
- B. Laboratory projects
  - 1. Obtain samples of residential, commercial, market and combined refuse. Separate into standard categories and determine the percent composition.
  - 2. Determine the moisture content, pH value, volatile solids and ash, and heating value.
  - 3. Compare the results obtained and determine feasibility of salvage operations and optimum method for disposal.
  - 4. Extrapolate generation rates to the total community and the nation and compare with the results of published studies.

III. Solid Waste Collection

- A. Units of instruction
  - 1. Pre-collection practices
    - a. Separation into categories
      - (1) Ease of handling
      - (2) Sanitation
      - (3) Salvaging
      - (4) Effect on disposal method
    - b. Containers
      - (1) Maximum size
      - (2) Minimum size
      - (3) Materials of construction
      - (4) Handles and lids
    - c. Storage point of refuse
      - (1) Alley
      - (2) Yard
      - (3) Basement
      - (4) Other
    - d. Point of collection
  - 2. Refuse collection systems
    - a. Municipal
      - (1) Advantages
      - (2) Disadvantages
    - b. Contract
      - (1) Advantages
      - (2) Disadvantages
    - c. Private
      - (1) Advantages
      - (2) Disadvantages
  - 3. Collection methods
    - a. Pickup at curb or alley
    - b. Set out and set back
    - c. Backyard service
    - d. Commercial service
  - 4. Factors affecting collection costs
    - a. Frequency of service
      - (1) Increased labor with increasing frequency
      - (2) Public health aspects
    - b. Degree of service
    - c. Location of container
    - d. Haul distance
    - e. Local conditions
      - (1) Allowable truck speed
      - (2) Topography
      - (3) Street conditions
      - (4) Climate
      - (5) Population density
    - f. Labor costs
    - g. Standard of living
  - 5. Collection equipment
    - a. Refuse conveyance types
      - (1) Open top trucks

(2) Enclosed noncompactor trucks
(3) Enclosed compactor trucks
(4) Portable bulk containers
(5) Can carrier trucks
(6) Trains
b. Factors affecting equipment selection
(1) Number and capacity of vehicles required
(2) Capital investment cost
(3) Operating cost
(4) Maintenance cost
(5) Useful life
(6) Safety and comfort of crews
(7) Climate
(8) Nature of community
(9) Method of disposal

B. Laboratory Projects
1. Visit a municipal Public Works Department or similar department with responsibilities for solid waste collection and disposal.
2. Make notes of the number of collection vehicles used, types and capacities.
3. Determine crew size, frequency of pickup and degree of service provided.
4. On a city map, sketch out representative routes, population and service densities and travel times.
5. Determine method of coordinating refuse collection with disposal.

IV. Reduction and Disposal Methods

A. Units of instruction
1. On-site disposal
a. Incineration
(1) Advantages and disadvantages
(2) Home units
(3) Commercial incinerators
(4) Hospital (pathological) incinerators
(5) Apartment incinerators
(6) Miscellaneous types
b. Garbage grinding
(1) Advantages and disadvantages
(2) Effects on water supply system
(3) Effects on sewers
(4) Effects on sewage treatment plant
(5) Costs
2. Central incineration
a. History
b. Evaluation
(1) Advantages
(2) Disadvantages
c. Terminology and components
(1) Refuse weighing and storage
(2) Refuse conveyors
(3) Charging devices
(4) Furnace types
(5) Residue handling facilities
(6) Pollution control devices
(7) Flue and chimney
(8) Accessory equipment
d. Costs
(1) Equipment
(2) Construction
(3) Operating
(4) Maintenance
(5) Salvage potential
e. Combustion technology
(1) Heating value of refuse
(2) Time, temperature, turbulence considerations
(3) Air requirements
(4) Sizing and design considerations
(5) Heat balance and auxiliary fuels
(6) Heat recovery
(7) Control devices
3. Sanitary landfill operations
a. Distinction between sanitary landfills and open dumping
(1) ASCE definition
(2) PHS requirements
(3) APWA standards
b. Public health factors
(1) Vector control
(2) Air pollution
(3) Groundwater pollution
(4) Fire hazards
(5) Nuisance aspects
c. Factors affecting location
(1) Availability of suitable land
(2) Topography and accessibility
(3) Geology
(4) Drainage and groundwater level
(5) Availability of cover material
(6) Public acceptance
d. Landfill methods
(1) Area
(2) Trench
(3) Ramp
(4) Special methods
e. Facilities
(1) Access roads
(2) Fences
(3) Weighing facilities
(4) Fire control
(5) Personnel
f. Equipment types
(1) Crawler tractor
(2) Rubber tired tractor

(3) Dragline
(4) Scraper
(5) Steel wheeled compactor
(6) Accessory equipment
g. General considerations
(1) Personnel
(2) Costs of operation
(3) Seasonal operation
(4) Wet weather operations
(5) Settlement and decomposition factors
(6) Reclamation value of site
4. Composting
a. General aspects
(1) Historical development
(2) Definition of composting process
(3) Advantages of composting
(4) Disadvantages of composting
(5) Prevalence of composting
b. Economic considerations
(1) High operating and capital costs
(2) Salvage material from refuse
(3) Value of finished compost
(4) Comparison with other methods
c. Composting methods
(1) Areal
(2) Mechanical
d. Technical fundamentals
(1) Temperature
(2) Digestion time
(3) Aeration
(4) Biological processes
(5) Moisture content
e. Composting operations
(1) Weighing facilities
(2) Unloading and storage
(3) Sorting and salvage operations
(4) Grinding
(5) Moisture control
(6) Digestion process
(7) Storage and marketing
5. Miscellaneous methods
a. Refuse grinding
(1) Municipal
(2) Commercial
(3) Junk auto disposal
(4) Repulping of paper
(5) Costs
(6) Public health and nuisance aspects
(7) Evaluation as a disposal method
b. Hog feeding
(1) Prevalence of hog feeding
(2) Public health problems
(3) Cooking garbage
(4) Equipment requirements
(5) Costs
(6) Effect on refuse collection systems
c. Open dumping
d. Open burning
6. Factors affecting disposal method
a. Technical feasibility
b. Economic feasibility
c. Public health considerations
d. Climatic conditions
e. Effect of collection costs
f. Salvage value
g. Completeness of the disposal method
h. Public acceptance
B. Laboratory projects
1. Visit a municipal incinerator (or commercial incinerator, or hospital pathological incinerator) and make a sketch of the process, labeling major parts and components.
2. Determine the capacity of the installation, grate area and use of auxiliary fuels.
3. Locate and count the underfire and overfire air ports, auxiliary blowers, dampers, etc.
4. Determine the types of air pollution control equipment used, and if possible, the efficiencies.
5. Determine the amount of residue produced and disposal practices.

V. Salvage Operations

A. Units of instruction
1. Advantages of salvaging
a. Reduction in cost of disposal operation
b. Conservation of resources
c. Reduction in volume of refuse
2. Disadvantages of salvaging
a. Possible nuisance creation
b. Fluctuating market conditions
c. Increased handling of refuse
d. Economic considerations
3. Salvageable materials
a. Rags
b. Paper
(1) Newspaper
(2) Cardboard
(3) Books and magazines
c. Glass
d. Metal
(1) Ferrous

(2) Nonferrous
(3) Junk autos
e. Rubber
f. Garbage and animal waste
g. Ashes and cinders
4. Effect of salvage operations on disposal method
a. Incineration
(1) Removal of garbage
(2) Removal of paper and rags
(3) Removal of metals and glass
(4) Removal of rubber
(5) Waste heat utilization
b. Composting
(1) Salvage at compost plant
(2) Compostable materials
(3) Non-compostable materials
c. Sanitary landfill operations
(1) Salvage at landfill
(2) Volume of landfill material
(3) Decomposition rates
(4) Stability of landfill
5. General considerations
a. Aesthetics
b. Safety
c. Public health
d. Control of scavenging
e. Economics vs. conservation of resources
B. Laboratory projects
1. Visit a junk auto reclamation operation and compare several methods of salvaging junk autos (Compaction vs. mechanical shredding) from the standpoint of economics, efficiency, air pollution, etc.
2. Visit a rubber (or paper) reclaiming or salvaging operation and note procedures and methods, efficiencies, nuisance conditions, etc.

VI. Management of Disposal Systems

A. Units of instruction
1. Organization
a. Methods of structuring
b. Staffing
c. Lines of authority
d. Authority—responsibility relationships
e. Coordination of collection and disposal
2. Administration
a. Personnel
(1) Job requirements
(2) Salary levels
(3) Promotion procedures
(4) Training programs
(5) Safety programs
b. Fiscal responsibilities
c. Reporting procedures
d. Auxiliary services
3. Public relations
a. Importance to waste disposal program
b. Methods of securing good public relations
c. Complaint processing
B. Laboratory projects
1. Visit a sanitary landfill operation and note how it is conducted.
2. Determine the type operation, equipment used, compaction procedures, source of cover material, depth of cover and frequency of cover.
3. Determine haul distance and make a sketch of a typical cell, with approximate dimensions.
4. Visit a compost plant and prepare a flow diagram of the process. Note weighing, unloading and storage facilities. Observe refuse handling, salvaging and moisture control procedures. Make notes on grinding or shredding equipment, digester size and average digestion time. Determine the method of aeration, digestion temperatures, and disposal of the finished compost.

Texts and References

AMERICAN PUBLIC WORKS ASSOCIATION. *Municipal Refuse Disposal.* ——. *Refuse Collection Practice.*
CATERPILLAR TRACTOR COMPANY. *Machine Selection Guide: Sanitary Landfill. Recommended Standards for Sanitary Landfill Operations.*
SORG AND HICKMAN. *Sanitary Landfill Facts.*
American City.
American Public Works Association Reporter.
American Public Works Association Yearbook.
American Society of Civil Engineers Sanitary Engineering Division Journal.
Compost Science.
Public Works.
Solid Wastes Management.

Visual Aids

(Films are color, unless black and white is noted.)

U. S. Public Health Service, Audiovisual Facility, Atlanta, Ga. 30333
A Day at the Dump, M-1600 X., 16 mm., 15 min., sound.
A Survey of Refuse Disposal Methods, M-328, 16 mm., 10 min., sound.
Incineration, M-353, 16 mm., 13 min., sound.
Refuse Disposal by Sanitary Landfills, M-228, 16 mm., 13 min., sound.
Sanitary Storage and Collection of Refuse, M-4, 16 mm., 19 min., sound.
Sanitation Techniques in Rat Control, M-37, 16 mm., 12 min., b/w, sound.

TECHNICAL REPORTING

Hours Per Week

Class, 2

Description

This course, an extension of *Communication Skills*, is intended to help the student achieve greater facility in the basic skills he previously acquired. It introduces the student to the practical aspects of preparing reports and communicating within groups. The use of graphs, charts, sketches, diagrams, and drawings to present ideas and significant points is an important part of this course. Emphasis should be upon techniques for collecting and presenting scientific data in informal and formal reports and special types of technical papers. Forms and procedures for technical reports should be studied, and a pattern established for all forms to be submitted in this and other courses.

Much of the subject matter will probably be reports written for technical courses. The subject matter in this course should be coordinated with course work and laboratory techniques presented in the air pollution technology specialty.

Major Divisions

		Class hours
I.	Introduction to Reporting	3
II.	Writing Technical Reports	12
III.	Use of Visual Aids in Reports	4
IV.	The Research Report	3
V.	Special Problems in Oral Reporting	4
VI.	Conferences and Briefings	6
	Total	32

I. Introduction to Reporting

A. Nature and types of reports
B. Importance of reports
  1. Importance of accuracy and objectivity in observation and recording
  2. Legal importance of recorded data and log books
C. Purpose of reports
  1. Readers' needs and types of readers
  2. Background situations of reports

II. Writing Technical Reports

A. Characteristics of Technical Reports
  1. Conciseness
  2. Objectivity
  3. Clarity
  4. Completeness
  5. Readibility
  6. Accuracy
B. Informal reports
  1. Written short-form reports
    a. Memorandum reports
    b. Business letter reports
    c. Progress reports
    d. Outline reports
  2. Oral reports
    a. To individuals
    b. To groups
C. Formal reports
  1. Arrangement
    a. Cover and title page
    b. Table of contents
    c. Summary and recommendations
    d. Body of the report
    e. Bibliography and appendix
    f. Graphs, drawings, illustrations
  2. Preparation
    a. Collecting, selecting, arranging material
    b. Writing and revising the report
      (1) Proper usage of:
        (a) Vocabulary
        (b) Capitalization
        (c) Abbreviation
        (d) Punctuation
        (e) Symbols and numerals
        (f) Grammar
      (2) Correcting factual errors
      (3) Editing and checking the final draft
D. Typical problems in writing
  1. Definitions
  2. Statements of problems, principles and conditions
  3. Descriptions and narratives
  4. Proposals
  5. Inspection reports
  6. Process explanations
  7. Comparisons
E. Precautions to be observed
  1. Confidential information
  2. Classified information
  3. Copyrights and trademarks
  4. Liability

III. Use of Visual Aids in Reports

A. Importance of visual aids in written and

oral reports
B. Types of visual aids
  1. Tables
  2. Engineering drawings
  3. Flow diagrams
  4. Graphs and charts
  5. Photographs
C. Selection of appropriate visual aids
  1. Availability
  2. Time and cost of preparation
  3. Clarity of presentation
D. Projection or other use of visual aids for oral reports
  1. Readability
  2. Clarity
  3. Contrast
  4. Timing

IV. The Research Report

A. Purposes
B. Source materials
  1. Bibliographies
  2. Periodical indexes
  3. The library
C. Organization
  1. A working bibliography
  2. Footnotes and references
  3. Outline
  4. Rough draft
  5. Final paper
D. Oral and written presentation

V. Special Problems in Oral Reporting

A. Organization of material for effective presentation
B. Preparation of formal and informal oral reports
C. Use of notes
D. Use of slides or other visual aids
E. Proper control of the voice
F. Proper control of the body: gesticulation
G. Elimination of objectionable mannerisms
isms
H. Maintenance of audience interest
I. Testifying in court

VI. Conferences and Briefings

A. Group communication
  1. Leading conferences: rules of order
  2. Participating in conferences
  3. Solving problems in conferences and meetings
B. Briefings
  1. Arranging and preparing briefings and presentations
  2. Conducting briefings and presentations

Texts and References

BROWN, *Communicating Facts and Ideas in Business.*
GRAVES AND HOFFMAN, *Report Writing.*
HAYS, *Principles of Technical Writing.*
RHODES, *Technical Report Writing.*
WEISS AND McGRATH, *Technical Speaking.*
ZETLER AND CROUCH, *Successful Communication in Science and Industry.*

Visual Aids

U. S. Environmental Protection Agency, Technical Audio Visual Branch, Research Triangle Park, N.C. 27711.
Roll of the Witness, MA-68, 16 mm., 45 min., color, sound.

GENERAL COURSES

COMMUNICATION SKILLS

Hours Per Week

Class, 3

Description

The course emphasizes exercises in writing, speaking, and listening. Analysis is made of each student's strengths and weaknesses. The instruction is planned principally to help students improve skills in which they are weak. The time allotments for the various elements within major divisions will depend upon the background of the class. Technical reporting should be considered early in the course because of its importance in the orientation of the technician to his development and use of communication skills.

Major Divisions

	Class Hours
I. Communication and the Technical Specialist	2
II. Sentence Structure	6
III. Use of Resource Materials	4
IV. Written Expression	20
V. Talking and Listening	10
VI. Improving Reading Efficiency	6
Total	48

I. Communication and the Technical Specialist

- A. Summary of the technical specialist's need for proficiency in communication
- B. Discussion of written communication as an essential skill
    - 1. Statements and facts
    - 2. Expression of ideas
    - 3. Technical reporting
        - a. Formal
        - b. Informal
    - 4. Use of graphics to illustrate written communications
- C. Discussion of oral communications as an essential skill
    - 1. Person-to-person expression of ideas and thoughts
    - 2. Verbal reporting
- D. Diagnostic testing of students

II. Sentence Structure

- A. Review of basic parts of speech
- B. Study of complete, clear, and correct sentences
- C. Use and placement of modifiers, phrases, and clauses
- D. Study of sentence conciseness
- E. Exercises in sentence structure

III. Using Resource Materials

- A. Orientation in use of school library
    - 1. Location of reference materials
    - 2. Mechanics for effective use
    - 3. Dewey Decimal System (or Library of Congress system, as appropriate)
- B. Study of use of dictionaries
    - 1. Types of dictionaries
    - 2. Use of dictionaries
    - 3. Meanings of diacritical markings and accent marks
- C. Introduction to other reference sources
    - 1. Technical manuals and pamphlets
    - 2. Bibliographies
    - 3. Periodicals
    - 4. *Applied Science and Technology; Readers' Guide*, and other indexes
    - 5. Technical handbooks
    - 6. Standards and specifications
- D. Exercises in use of resource materials
    - 1. Card catalog
    - 2. *Readers' Guide* and other indexes
    - 3. Atlases
    - 4. Encyclopedias; dictionaries
    - 5. Other resources

IV. Written Expression (emphasis on student exercises)

- A. Diagnostic testing of students
- B. Study of paragraph construction
    - 1. Development
    - 2. Topic sentence
    - 3. Unity, coherence
- C. Study types of expression
    - 1. Narration, description, and exposition
    - 2. Inductive and deductive reasoning; syllogisms
    - 3. Figures of speech; analogies; comparisons and contrasts
    - 4. Cause-and-effect reasoning
    - 5. Other
- D. Written exercises in paragraph construction
- E. Study of descriptive reporting
    - 1. Organization and planning
    - 2. Emphasis on sequence, continuity, and delimitation to pertinent data or information
- F. Study of letter writing
    - 1. Business letters
    - 2. Personal letters
- G. Review of mechanics
    - 1. Grammar (reviewed as required)
    - 2. Punctuation—when to use
        - a. Period, question mark, and exclamation point
        - b. Comma
        - c. Semicolon
        - d. Colon
        - e. Dash
        - f. Parentheses
        - g. Apostrophe
    - 3. Capitalization
    - 4. Spelling
        - a. Word division—syllabification
        - b. Prefixes and suffixes
        - c. Word analysis and meaning—context clues and phonetics
- H. Exercises in mechanics of written expression

V. Talking and Listening (emphasis on student exercises)

- A. Diagnostic testing of students
- B. Organization of topics or subjects
- C. Directness in speaking
- D. Gesticulation and use of objects to illustrate
- E. Conversation courtesies
- F. Listening faults
- G. Taking notes
- H. Understanding words through context clues

I. Exercises in talking and listening

VI. Improving Reading Efficiency
A. Diagnostic testing of students
B. Improvement of reading habits
1. Correct reading posture
2. Light sources and intensity
3. Developing proper eye-span and movement
4. Developing speed and comprehension appropriate to the purpose
5. Scanning: sentence reading
6. Taking notes for careful study
C. Footnotes, index, bibliography, and cross-references
D. Developing skill in summarizing
1. Outline
2. Digest or brief
3. Criticism
E. Exercises in reading improvement
1. Reading for comprehension
2. Reading for speed

Texts and References

BAIRD AND KNOWER. *Essentials of General Speech.*
BEARDSLEY. *Thinking Straight: Principles of Reasoning for Readers and Writers.*
BUCKLER AND McAVOY. *American College Handbook of English Fundamentals.*
COWAN. *Plain English Please.*
DEAN AND BRYSON. *Effective Communication.*
DEVITIS AND WARNER. *Words in Context: A Vocabulatory Builder.*
GRIGGS AND WEBSTER. *Guide and Handbook for Writing.*
HODGES AND WHITTEN. *Harbrace College Handbook.*
KIRSCHBAUM. *Clear Writing.*
LEGGETT, MEAD, AND CHARVAT. *Handbook for Writers.*
PERRIN AND SMITH. *Handbook of Current English.*
ROGET. New Roget's Thesaurus of the English Language.
STEWART AND OTHERS. *Business English and Communication.*
THOMAS. *Composition for Technical Students.*
WATKINS, MARTIN, AND DILLINGHAM. *Practical English Handbook.*
WITTY. *How to Become a Better Reader.*
ZETLER AND CROUCH. *Successful Communication in Science and Industry: Writing, Reading and Speaking.*
A current dictionary.

Visual Aids

Coronet Films, Inc., Coronet Building, Chicago, Ill. 60601.
Improve Your Punctuation, 16 mm., 11 min., sound, b/w or color.

National Education Television Film Service, Audio Visual Center, Indiana University, Bloomington, Ind. 47405. (The following films are black and white)
The Definition of Language, 16 mm., 29 min., sound. Produced by Henry Lee Smith. (Language in Linguistics Series)
Dialects, 16 mm., 29 min., sound. Produced by Henry Lee Smith. (Language in Linguistics Series)
How to Say What You Mean, 16 mm., 29 min., sound. Produced by S. I. Hayakawa. (Language in Action Series)
Language and Writing, 16 mm., 29 min., sound. Produced by Henry Lee Smith. (Language in Linguistics Series)
The Task of the Listener, 16 mm., 29 min., sound. Produced by S. I. Hayakawa. (Language in Action Series)
What is the Meaning?, 16 mm., 29 min., sound. Produced by S. I. Hayakawa. (Language in Action Series)

DuArt Film Laboratories, Inc., 245 West 55th Street, New York, N.Y. 10019
Films which *may* be available for loan:
Effective Writing, 16 mm., 19 min., sound, b/w, U. S. Department of the Air Force. Order No. TF1-5072.
Practical English Usage I, Lecture 1: The Tools of Language, 16 mm., 30 min., sound, b/w.
Practical English Usage I, Lecture 10: Writing Clear Sentences: Making Words Agree, 16 mm., 30 min., sound, b/w.
Practical English Usage I, Lecture 13: Dressing Up Sentences: Parallelism: Avoidance of Shifts, 16 mm., 30 min., sound, b/w.
Practical English Usage I, Lecture 14: Dressing Up Sentences: Word Economy (Word Reduction), 16 mm., 30 min., sound, b/w.
Practical English Usage I, Lecture 15: Dressing Up Sentences: Variation, 16 mm., 30 min., b/w, sound.

INDUSTRIAL ORGANIZATIONS, INSTITUTIONS AND GOVERNMENT

Hours Per Week

Class, 3

Description

This course describes and analyzes the roles of labor and management in the economy of the United States. Approximately half of the classroom time is devoted to labor-management relations, including the evolution and growth of the American labor movement and the development and structure of American business management. A study is made of the legal framework within which labor-management relations are conducted and the responsibilities of each in a democratic system of government. The second half is devoted to labor-economics as applied to the forces affecting labor supply and demand, problems of unemployment and wage determination on the national, plant, company, and individual levels. Emphasis centers upon current aspects of industrial society, with historical references only as a background.

Major Divisions

	Class Hours
I. Labor in an Industrial World	9
II. Management in an Industrial Society	9
III The Collective Bargaining Process	12
IV. Dynamics of the Labor Market	8
V. Wage and Salary Determination	7
VI. The Balance Sheet of Labor Management Relations	3

I. Labor in an Industrial World

- A. The nature and scope of the Industrial Revolution
  - 1. The factory system
  - 2. Occupational trends
  - 3. Mechanisms of adjustments
- B. The evolution of American labor unions
  - 1. Nature of early unions; basic system of craft unions
  - 2. Organizations by unions for solving problems
  - 3. Development of business unionism
  - 4. The changing role of government
- C. Structure and objectives of American unions
  - 1. Objectives in collective bargaining
  - 2. Political objectives and tactics
  - 3. Structure of craft and industrial unions
  - 4. Movement toward unity—the AFL-CIO merger
  - 5. Conduct of local unions

II. Management in an Industrial Society

- A. The rise of big business
  - 1. Economic factors
  - 2. Dominance of the corporation
  - 3. Government, public policy, and big business
- B. The managerial revolution
  - 1. Changing patterns of ownership and management
  - 2. Scientific management
  - 3. Twentieth-century trends
- C. Structure and objectives of American industry
  - 1. Production for profit: an affluent society
  - 2. Structure of industry—organizational forms
  - 3. Ethics in a competitive economy

III. The Collective Barganing Process

- A. Legal framework
  - 1. Common law provisions
  - 2. The growth of statute laws
  - 3. National Labor Relations Board rulings
  - 4. Specific laws; court decisions
    - a. The antitrust laws; effects on collective bargaining
    - b. The Adamson and LaFollette laws
    - c. Norris-LaGuardia law
    - d. Walsh-Healy law
    - e. Wagner law
    - f. Fair Labor Standards law
    - g. Taft-Hartly law
    - h. Landrum-Griffin law and beyond
- B. Management and collective bargaining
- C. Bargaining procedures and tactics, including mediation
- D. Issues and areas of agreement in collective bargaining
  - 1. Security issues
  - 2. Working conditions

- 3. Safety provisions and safety education
- 4. Money matters

E. Strikes and lockouts: tactics and prevention

F. Evaluation of collective bargaining

IV. Dynamics of the Labor Market

A. Labor supply and the market
- 1. Level and composition of the labor force
- 2. Changing patterns of employment
- 3. Some questions about labor supply and the market

B. Reduction and control of unemployment
- 1. Types of unemployment
- 2. Proposed schemes of employment stabilization
- 3. Continuing problems

C. Labor mobility
- 1. Types of labor mobility
- 2. Deterrents to labor mobility
- 3. Suggested programs to improve labor mobility

V. Wage and Salary Determination

A. Wages, salaries, processes, and employment
- 1. Definition of wages and salaries
- 2. Wages and the productive process
- 3. The problem of inflation

B. Wages and the national income
- 1. Concepts of measurement and productivity
- 2. Determinants of productivity
- 3. Distribution of national income

C. Wage structures
- 1. Occupational differences
- 2. Geographic patterns
- 3. Industry patterns
- 4. Wage determination: plant level; individual wages

VI. The Balance Sheet of Labor-Management Relations

A. The control and elimination of poverty in a modern industrial state
- 1. The extent of poverty
- 2. The attack on poverty
- 3. Trends and portents

B. Justice and dignity for all in an industrial democracy
- 1. The worker—status and goals
- 2. Management—rights and responsibilities
- 3. The future of capitalistic society

Visual Aids

ADRIAN. *State and Local Governments.*
BACH. *Economics: An Introduction to Analysis and Policy.*
BIESANZ AND MAVIS. *Modern Society: An Introduction to Social Science.*
CARR, BERNSTEIN, AND MORRISON. *American Democracy in Theory and Practice.*
GEORGE. *Management in Industry.*
IRISH AND PROTHRO. *The Politics of American Democracy.*
MARK AND SLATER. *Economics in Action.*
OGG AND RAY. *Essentials of American Government.*
WALLETT. *Economic History of the United States.*

Texts and References

Encyclopaedia Britannica Films, 1158 Wilmette Avenue, Wilmette, Ill. 60091.

Man and His Culture, 16 mm., 15 min., sound, black and white.

Productivity—Key to Plenty, 16 mm., 20 min., sound, black and white.

McGraw-Hill Book Co., Inc., 330 West 42nd Street, New York, N.Y. 10036.

Social Classes in America, 16 mm., 16 min., sound, black and white.

The Rise of Organized Labor, 16 mm., 18 min., sound, black and white.

FACILITIES, EQUIPMENT, AND COSTS

General Planning of Facilities

Building and equipping adequate laboratories for teaching air pollution technology is expensive. Institutions initiating such a program may find it necessary or desirable to spread the building and acquisition expense of the laboratories over more than 1 year. Ideally, such laboratories will be built and completely equipped before the first class of students is enrolled. In practice, however, it is often more feasible for the institution to build the laboratories and install the permanent work stations, fume hoods, special utilities, and such equipment, and to provide only the minimum of laboratory equipment, such as analytical apparatus, balances, instruments, and air pollution control demonstration models as are required to begin the teaching program.

Two basic laboratory types are required for the special air pollution technology courses. The first is essentially a standard wet-chemistry analytical laboratory. The second is a larger, unit operations laboratory having more free working area and a higher ceiling for performing experiments involving larger pieces of equipment. It may be that an existing chemistry laboratory (capable of handling 25-30 students) can be used for the air pollution analytical laboratory. The unit operations laboratory, however, requires special plumbing and services and a large amount of free floor space. It is strongly recommended that in any case there should be no compromise in quality in the purchase of the permanently installed work stations, fume hoods and cabinets.

Since the laboratory equipment is not unusually heavy, there are no restrictions on the type of foundation required for the laboratories. Special utility requirements offer some restrictions in locating the facilities. Electrical services should provide both 110- and 220-volt current for the instrument and furnace rooms of the analytical laboratory and the workshop and main unit operations laboratory.

Both laboratories should be well lighted. A minimum of 70 foot-candles of light is recommended on all work surfaces of classrooms, offices, and laboratories. Fixtures should be selected to provide a comfortable, uniform light throughout the room; usually fluorescent-type light is the most satisfactory.

Temperature and humidity control equipment for the instrument room is very desirable. Air in the other areas should be within comfortable temperature and humidity ranges. Particular attention should be given to the amount of outside air furnished to keep the laboratory air suitably fresh. The furnace room should be exhausted adequately to maintain a comfortable working temperature and to remove fumes and water vapor released during dryings.

Faculty offices may best be placed in small clusters in close proximity to the laboratories. Construction or placement should provide adequate speech privacy and isolation from noises originating in the laboratories. As in the laboratories, air conditioning is desirable. Each faculty member should have a minimum of 150 square feet of office space.

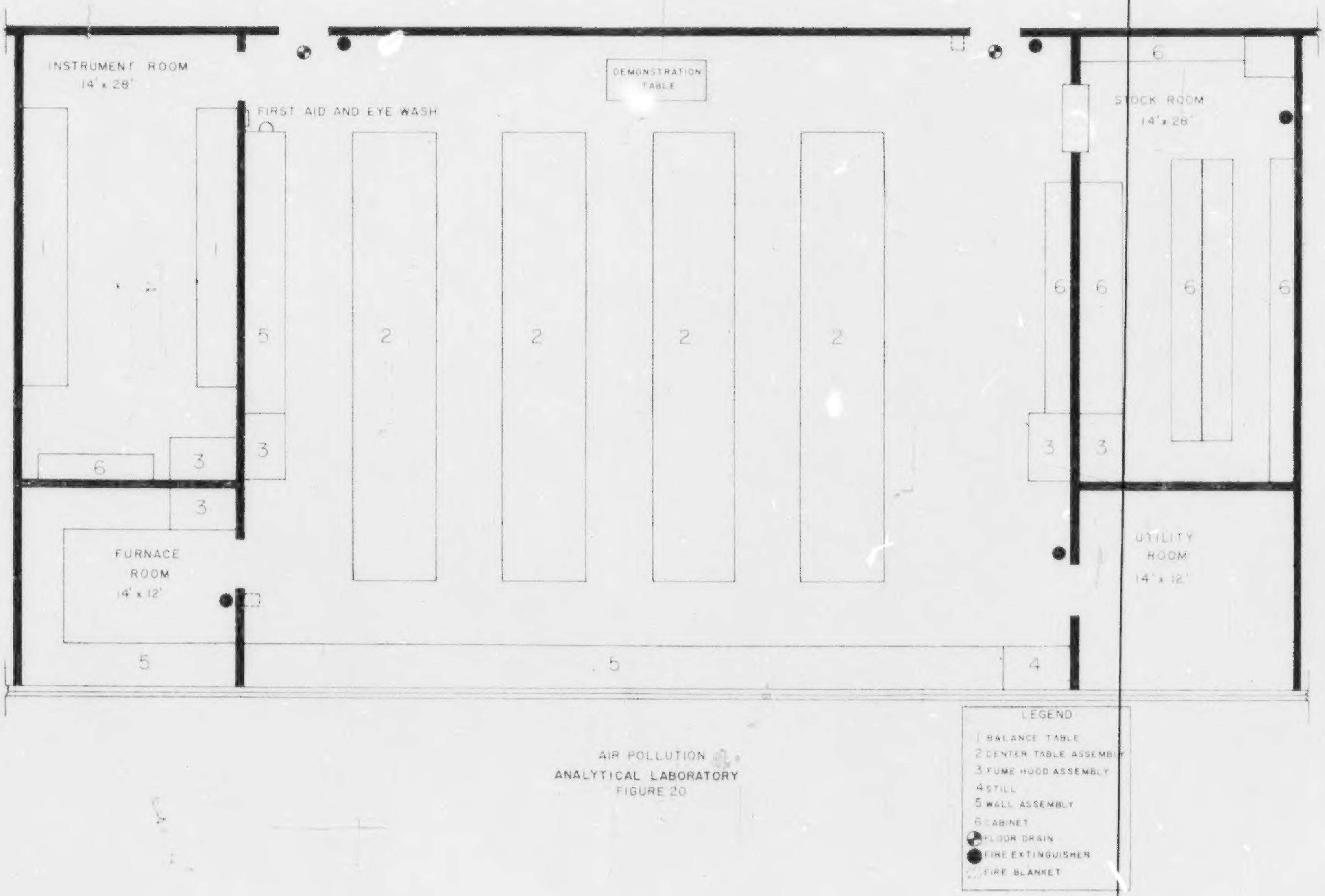
This discussion assumes that conventional classrooms, offices, lecture rooms, and the necessary related accommodations are already available. Therefore, only the physical facilities specifically identifiable with the technical specialty will be described. Since the classrooms, laboratory facilities, and laboratory equipment required for the physics, chemistry, and biology courses for air pollution technology are conventional, the details will not be presented here.

The requirements for the technical specialty are somewhat unusual. Therefore, the minimum facilities and equipment needed are described in some detail. Facility plans and estimates are based on 24 students—the maximum number recommended in the specialty courses. If the facilities are available, lecture courses may be larger, possibly up to 50 students. Some laboratory sections may be smaller than 24 students depending on the nature of the experiments to be performed.

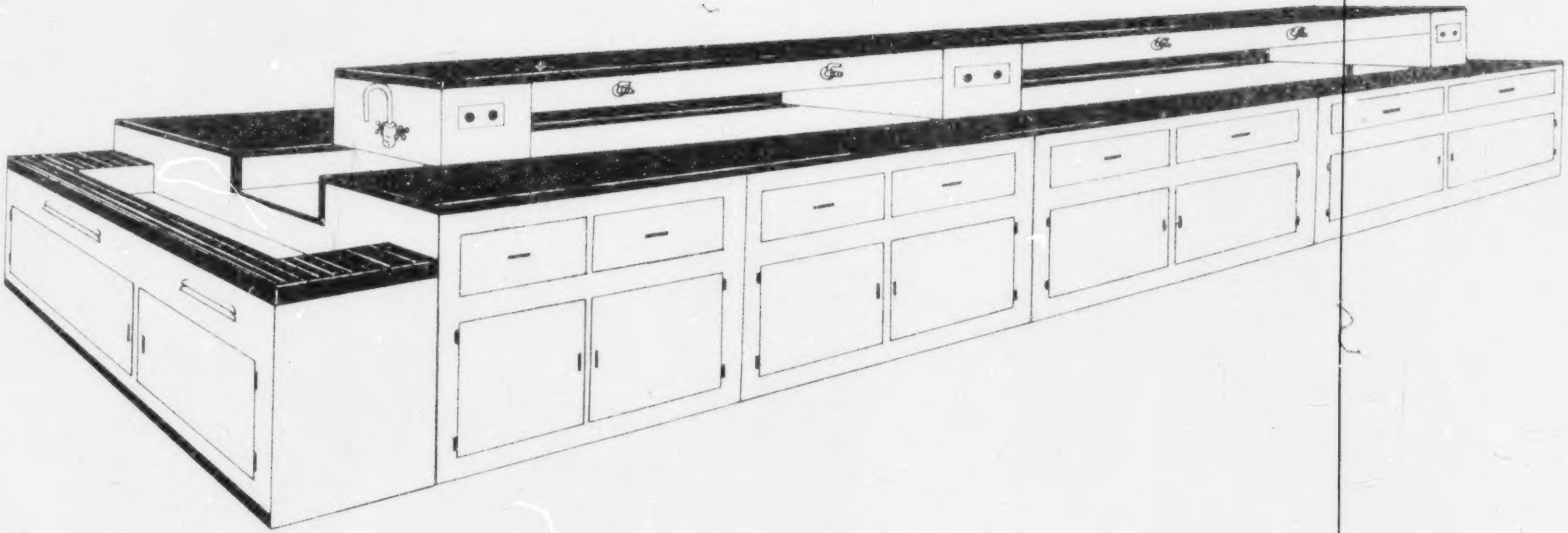
Air Pollution Analytical Laboratory

A typical floor plan for an analytical laboratory is shown in Figure 20. The floor plan in Figure 20 calls for adequate work space and safety. Four center table assemblies are recommended for the main laboratory area. Figure 21 is an illustration of a typical center table assembly. As shown in Figure 20, a standard chalk board is located on the front wall and a demonstration table is provided to allow the instructor to demonstrate experiments and equipment arrangements.

The instrument room should be located immediately adjacent to the main laboratory area so students do not have to leave the laboratory area to use the balances and other analytical instrumentation. This room should be provided with temperature and humidity controls to avoid inaccuracies in the use of analytical balances or other instruments arising from changes in temperature or humidity. This room should also be



AIR POLLUTION
ANALYTICAL LABORATORY
FIGURE 20



CENTER TABLE ASSEMBLY

FIGURE 21

light proof. The room should be furnished with solidly built balance tables to provide adequate stability for the analytical balances. Also located in this room are storage cabinets for auxiliary items associated with the use of the instruments. A fume hood assembly is recommended for specialized instrumentation work involving the use of volatile gases, see Figure 22.

Since many analytical and sampling procedures in air pollution technology require the use of drying ovens or furnaces, a special furnace room is found adjacent to the main laboratory area, see Figure 23. Atmospheric pressure ovens, muffle furnaces and hot plates are available in this room.

The stock room and utility room are located at the opposite end of the main laboratory area. The stock room should be well equipped with cabinets for storing laboratory equipment and chemicals. Delicate glassware and dangerous chemicals should be kept in the stockroom and checked out as needed. Extra glassware, rubber and glass tubing, and miscellaneous laboratory supplies should also be stored here. The utility room may be used for storing brooms and other cleaning utensils, storing cylinders of compressed gas, or housing an air compressor if needed. It may also afford access to main steam valves, compressed air valves, gas valves, or electric circuit breakers which furnish utilities to the air pollution laboratory.

Air Pollution Unit Operations Laboratory

The floor plan for the unit operations laboratory is shown in Figure 24. This floor plan calls for a large open space to accommodate the fan test apparatus, air pollution control equipment models, and any other large pieces of equipment necessary for demonstrating and performing experiments in air pollution sampling and control. Cabinets, workbenches and tables occupy part of the perimeter of the work area. Since the room is designed for the use of portable demonstration units, an overhead system for furnishing utilities is required. Connections for electricity, gas, water, steam and air are recommended.

Adjacent to the work area are the workshop and the storage room. The storage room is used to store demonstration models and air pollution sampling equipment. The workshop should have a good assortment of hand and power tools. Larger power tools such as lathes, drill presses, and bench saws are optional and could be added later in the program as required. A supply of pipe fittings, tube connectors, and similar hardware may also be kept in the workshop.

Equipping and Estimating the Cost of Laboratories

Ideally, a program should start with fully equipped laboratories, but if necessary, the required laboratories can be equpped as the program develops; the outlay of funds before the first year of the program is thus reduced to a minimum the first year, and the costs of equipment needed for the second year can be spread over the first year's operation.

Experience has shown that the department head or one of the technical specialty instructors is the best qualified person to make final decisions on the selection of laboratory equipment. His background in the technical specialty will usually prevent costly mistakes which often occur when nontechnical employees select or buy equipment.

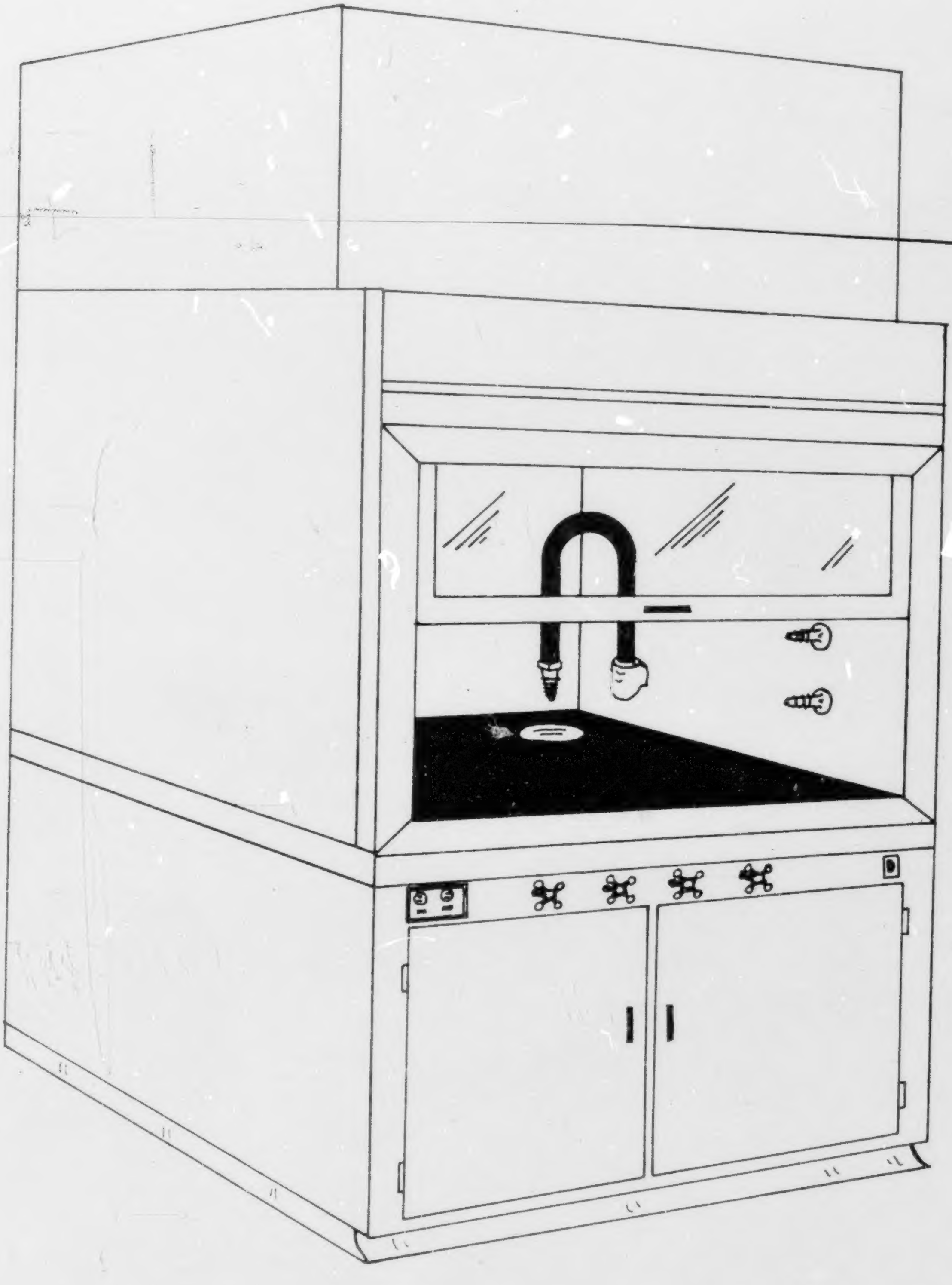
Surplus equipment, from either private or public organizations, can be an important source of good materials and hardware for equipping laboratories. Government surplus property may often be an especially attractive source of either standard or specialized components, units, assemblies, mechanisms, instruments, and systems— the cost of which usually is only a small fraction of the cost when new. Educational institutions are high on the priority list of agencies to which governmental surplus property is available. Information on government surplus property may be obtained from the State Director of Vocational and Technical Education or by writing to:

Chief, Surplus Property Utilization Division
U.S. Department of Health, Education and Welfare
Washington, D.C. 20201

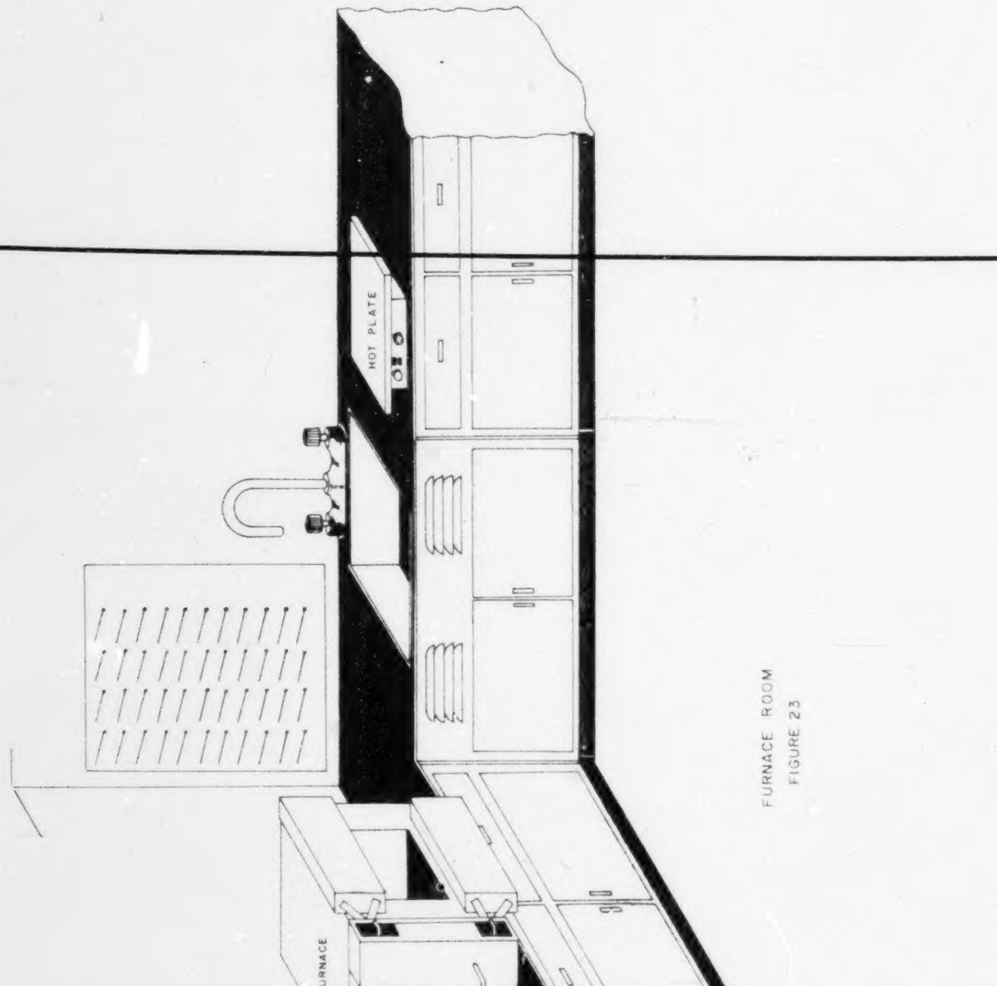
Suppliers of chemical laboratory equipment may be found in the *Thomas Register*, or any other comprehensive listing of suppliers of chemical and scientific laboratory equipment.

The estimates that follow are based on the costs of equipping air pollution laboratories for 24 students, with new equipment of good quality. The estimates are based on the purchase price at the date of this publication. The estimates do not include costs of office furniture, conventional classrooms, and rooms or laboratories necessary for the auxiliary or supporting science courses. They are specifically for laboratories and rooms needed for the technical specialty.

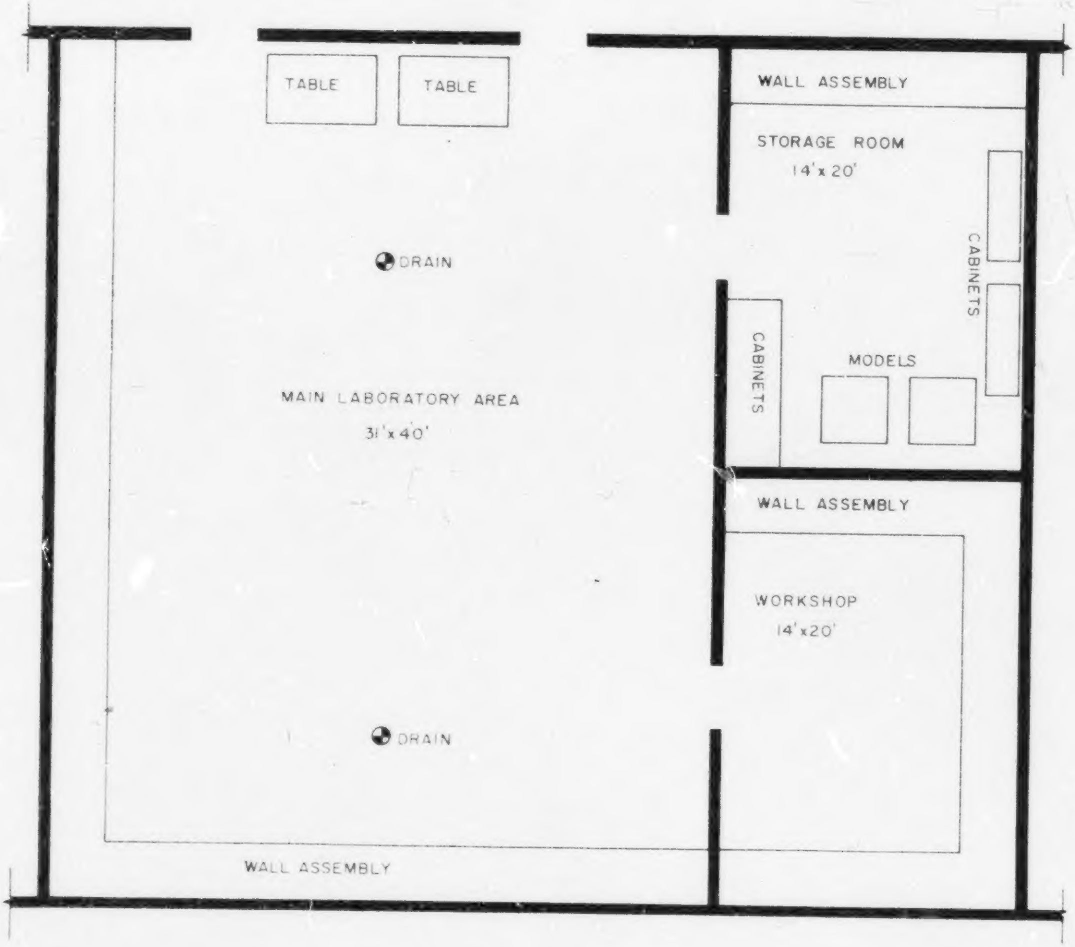
Major items of equipment necessary for each laboratory are listed, and an estimate of their cost is given below as a gross figure with a rea-



FUME HOOD
ASSEMBLY
FIGURE 22



FURNACE ROOM
FIGURE 23



AIR POLLUTION
UNIT OPERATIONS
LABORATORY
FIGURE 24

sonable range to reflect variations in costs of brand names and local areas. Since comparable items of equipment may vary in cost in various locations, individual items are not priced. Costs of equipment may vary also if purchased in larger quantities. Minimum equipment costs and costs of optional equipment are also given.

ESTIMATES FOR SPECIFIC FACILITIES

AIR POLLUTION EQUIPMENT AND SUPPLIES

Basic Chemical Laboratory Equipment
Cabinet Inventory

Item	*Number required*
Beakers, 100 ml	48
Beakers, 250 ml	48
Beakers, 400 ml	48
Beakers, 600 ml	36
Beakers, 1000 ml	24
Beakers, 2000 ml	12
Bottles, wash, plastic	12
Bottles, dropping, 15 ml	180
Bottles, sample, 4 oz	36
Bottles, storage, 1/2 gal	12
Bottles, reagent, 250 ml	18
Brush Assortment	1
Burette, student, 50 ml	12
Burner, Bunsen	12
Clamp, pinchcock	12
Clamp, test tube	12
Clamp, utility	6
Clamp, thermometer	6
Clamp, burette	6
Crucible, porcelain	12
Crucible cover, porcelain	12
Crucibles, Gooch	36
Holder, Gooch	6
Cylinder, graduated, 10 ml	6
Cylinder, graduated, 50 ml	6
Cylinder, graduated, 100 ml	6
Cylinder, graduated, 500 ml	6
Droppers, medicine	24
Dish, evaporating	12
File, triangular	3
Condensers	6
Flask, Erlenmeyer, 125 ml	12
Flask, Erlenmeyer, 250 ml	24
Flask, Erlenmeyer, 500 ml	12
Flask, Florence, 500 ml	6
Flask, Florence, 1000 ml	6
Flask, volumetric, 100 ml	6
Flask, distilling, 50 ml	6
Flask, distilling, 125 ml	6
Flask, distilling, 250 ml	6
Flask, distilling, 500 ml	6
Flask, distilling, 1000 ml	6
Funnel, filtering	36
Funnel, separatory, 125 ml	6
Funnel, separatory, 500 ml	6
Funnel, Buchner	6
Gauze, wire	40
Glass plates	40
Watch glasses, 5"	40
Glass plates, cobalt	6
Spot plates	6
Litmus paper	36
Ring, 4"	6
Ring, 5"	6
Ring, 6"	6
Ring stand	24
Rubber stopper assortment	6
Spatula	12
Spoon, deflagrating	6
Support, test tubes	12
Test tubes, pyrex, 3"	120
Test tubes, pyrex, 1" X 6"	60
Thermometer assortment (12)	1
Thistle tube tops	6
Tong, crucible	12
Triangle, wire and clay	30
Hydrometers, assortment	1
Desiccator	6
Stirring rods and rubber policemen	24
Distilling column	6
Pipet assortment	1
Cork rings	6
Funnel support	6
Tubing, rubber, assortment	1
Tubing, glass, assortment	1
Mortars and pestles	3

Estimated Cost of Cabinet Inventory—total, $2,000 to $2,500

Laboratory Equipment

Water still	1
Fume Hood Assembly	2
Lab wagon	4
Electric stirrers	6
Balances, triple beam, capacity 311 grams, sensitivity, 0.01 gram	6
Blenders, electric	6

Safety Equipment

Showers	2
Shields	10
Goggles	25
Fire blankets	25
Fire extinguishers	5
Eye washing fountain	1
First aid cabinet	1

Estimated Cost of Laboratory Equipment—total, $6,500 to $7,000

Furnace Room Equipment

Oven, drying, gravity convection 40°-200° C range	2
Hot Plate, three heat, 750°F approximately 14 5/8" X 23 3/4"	4
Furnaces, muffle, 9 1/2" X 8 1/2" X 13 1/2" chamber	2
Fume Hood	1
Balance, triple beam, capacity 311 grams, sensitivity, 0.01 gram	1
Miscellaneous assorted items – asbestos gloves, tongs and asbestos pads	

Estimated cost – total $4,000 to $4,500

Instrument Room Equipment	*Number required*	*Number optional*
Balances, digital balance 0.1 mg sensitivity	3	
pH meters	3	6
Microscope, student	2	6
Spectrophotometer, 320-1000-millimicron range	1	
infra-red, recording		1
Atomic absorption spectrophotometer, complete		1
Refractometer		1
Gas chromatograph		1
Transmissometer	2	
Dust counter, light scattering		1
Wind speed and direction indicators (Cost includes outside equipment)	1	

Plus examples of pressure and vacuum gages, thermocouples, and demonstration devices for aids in studying instrumentation.

Estimated Cost of Required Equipment – total $ 9,000 to $10,000

Estimated Cost of Optional Equipment – total $26,000 to $27,000

Total Estimated Cost of Instrument Room Equipment – total $35,000 to $37,000

Unit Operations Laboratory

Air Pollution Control Equipment, Demonstration

Item	*Number required*	*Number optional*
Cyclone Model, plexiglass, 50 cfm	1	
Venturi wet scrubber, plexiglass, 150 cfm	1	
Impingement plate scrubber model, plexiglass, 3 plates, 80 cfm	1	
Bag filter model, plexiglass, 25 cfm	1	
Packed tower model, plexiglass, 100 cfm	1	
Electrostatic precipitator model	1	
Gas Flow Measurement Equipment		
Fan test apparatus	1	
Dry gas meters	4	
Wet test meters	1	2
Air velocity Kit (including pitot tube & inclined manometer)	2	4
Barometer, mercurial	1	
Thermometers, wet and dry-bulb, assortment	1	
Sling psychrometer	3	
Air Pollution Sampling Equipment		
Orsat apparatus	2	4
Dustfall containers and stands	10	

Item	*Number required*	*Number optional*
High volume filter sampler and shelters	4	
Orifice calibration kit	1	2
Tape sampler	3	
Hydrogen sulfide unit		2
Rotorod assembly	5	
Cascade impactor	2	
Lead dioxide candle stations	10	
Sulfation plates holders	10	
Rubber cracking apparatus	10	
Corrosion plates	30	
Sampling probe, 4'	1	
Sampling probe, 8'	1	
Sampling nozzle, 1/4"	1	
Sampling nozzle, 3/8"	1	
Sampling nozzle, 1/2"	1	
Fabric panels	5	
Silver plates	5	
Membrane filters and holders	5	
Grab sampling vessels	10	
Greenburg-Smith Impingers	16	
Midget impingers	24	
Densitometers	2	
Andersen sampler	1	2
Ozone meter	1	2
24 hour sampler	1	2
Sequential sampler	1	2
Thermal precipitator sampler		1
Electrostatic precipitator sampler		1
Hydrocarbon analyzer		1
Vacuum pumps	3	6
Hygrothermometer	2	
Smoke generator		1

Plus an assortment of items such as stop watches, asbestos gloves, hoses, and clamps.

Estimated cost of required Unit Operations Equipment – total, $14,000 to $15,000

Estimated cost of optional equipment – total, $17,000 to $20,000

Total Estimated Cost of Unit Operations Equipment—total.	$31,000 to $35,000

Workshop area is to be equipped with various hand tools, power tools, and other specialized tools for plumbing, electrical work, and woodworking.

SUMMARY OF COSTS

In addition to the cost of basic equipment, a sum of $55,000 to $65,000 should be included for the cost of installing equipment and purchasing the special built-in laboratory assemblies. It is assumed that a continuing budget will be provided for repairs and maintenance of the laboratories.

The total cost of laboratories and equipment, excluding conventional classrooms and offices, for an air pollution technology program, based on 1971 prices, is estimated as follows:

Laboratory Facility	*Estimated Cost Required*	*Optional*
Air Pollution Analytical Laboratory		
Cabinets, work stations and other furnishings	$ 30,000 to $ 35,000	
Equipment	21,500 to 24,000	$ 26,000 to $ 27,000
Air Pollution Unit Operations Laboratory		
Cabinets, work stations and other furnishings	25,000 to 30,000	
Equipment	14,000 to 15,000	17,000 to 20,000
Total Estimated Cost	$ 90,500 to $104,000	$ 43,000 to $ 47,000
Total Estimated Cost of Required Facilities plus Optional Facilities	$133,500 to $151,000	

The foregoing estimates do not provide for the cost of the building itself; if it is constructed for the program, the cost may be roughly calculated at from $20 to $25 per square foot of unfurnished laboratory space.

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Appendix A

SUGGESTED LIBRARY CONTENT FOR THE TECHNOLOGY

The library content may be classified as basic encyclopedic and reference index material, reference books pertinent to air pollution technology, periodicals and journals, and visual aids.

Encyclopedic and Reference Index Material.

This part of the library content is basic in that it contains the broadly classified and organized cataloging of all available information pertinent to the objectives the library serves and the program it supports.

The following is a typical list of general reference material that might be found in a publicly controlled technical institute. Though many are general, some or all of these might appropriately be a part of the library which supports an air pollution technology program. This list is not complete, since it is presented as an example. In ordering any of the references, specify the latest edition.

AIR POLLUTION: A. C. Stern, Academic Press, Inc., 111 5th Avenue, New York, N.Y. 10003.

AIR POLLUTION ABSTRACTS: U.S. Government Printing Office, Washington, D.C. 20402.

AIR POLLUTION ENGINEERING MANUAL: Publication No. 999 AP 40, U.S. Government Printing Office, Washington, D.C. 20402.

AIR POLLUTION HANDBOOK: Paul L. Magill, et. al., McGraw Hill Book Co., Inc., 330 W. 42nd Street, New York, N.Y. 10036.

AIR POLLUTION INJURY TO VEGETATION: Hindawi, L. Publication No. AP 71, U. S. Government Printing Office, Washington, D.C. 20402.

AIR POLLUTION MEASUREMENTS OF THE NATIONAL AIR SAMPLING NETWORK: U. S. Government Printing Office, Washington, D.C. 20402.

AIR POLLUTION MANUAL PART I: EVALUATION: American Industrial Hygiene Association, 14125 Prevost Street, Detroit, Mich. 48227.

AIR QUALITY CRITERIA FOR CARBON MONOXIDE: Publication No. AP 62, U. S. Government Printing Office, Washington, D.C. 20402.

AIR QUALITY CRITERIA FOR HYDROCARBONS: Publication No. AP 64, U.S. Government Printing Office, Washington, D.C. 20402.

AIR QUALITY CRITERIA FOR PARTICULATE MATTER: Publication No. AP 49, U. S. Government Printing Office, Washington, D.C. 20402.

AIR QUALITY CRITERIA FOR PHOTOCHEMICAL OXIDANTS: Publication No. AP 63, U. S. Government Printing Office, Washington, D.C. 20402.

AIR QUALITY CRITERIA FOR SULFUR OXIDES: Publication No. AP 50, U. S. Government Printing Office, Washington, D.C. 20402.

AIR SAMPLING INSTRUMENTS: American Conference of Governmental Industrial Hygienists, 1014 Broadway, Cincinnati, Ohio 45237.

AMERICAN COLLEGE DICTIONARY: Random House, Inc., 457 Madison Avenue, New York, N.Y. 10022.

AMERICAN PUBLIC WORKS ASSOCIATION YEARBOOK: American Public Works Association, 1313 E. 60th Street, Chicago, Ill. 60637.

ANALYSIS OF AIR POLLUTANTS, THE: W. Leithe, Ann Arbor Science Publishers, Inc., Box 1425, Ann Arbor, Mich. 48106.

APPLIED SCIENCE & TECHNOLOGY INDEX: H. W. Wilson Co., 950 University Avenue, Bronx, N.Y. 10452.

ASTM STANDARDS: American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pa. 19103.

ATMOSPHERIC EMISSIONS FROM HYDROCHLORIC ACID MANUFACTURING PROCESSES: Publication No. AP-54, U. S. Government Printing Office, Washington, D.C. 20402.

ATMOSPHERIC EMISSIONS FROM NITRIC ACID MANUFACTURING PROCESSES: Publication No. 999-AP-27, U. S. Government Printing Office, Washington, D.C. 20402.

ATMOSPHERIC EMISSIONS FROM SULFURIC ACID MANUFACTURING PROCESSES: Publication No. 999-AP-13, U. S. Government Printing Office, Washington, D.C. 20402.

ATMOSPHERIC EMISSIONS FROM WET-PROCESS PHOSPHORIC ACID MANUFACTURE: Publication No. AP-57, U. S. Government Printing Office, Washington, D.C. 20402.

BIBLIOGRAPHY INDEX, THE: H. W. Wilson Co., 950 University Avenue, Bronx, N.Y. 10452.

BUSINESS PERIODICALS INDEX: H. W. Wilson Co., 950 University Avenue, Bronx, N.Y. 10452.

CHEMICAL ABSTRACTS: American Chemical Society, 1155 16th Street, N.W., Washington, D.C. 20006.

CHEMICAL ANALYSIS OF AIR POLLUTANTS, THE: M. B. Jacobs, Interscience Publishers, Inc. (John Wiley and Sons, Inc.) 605 Third Avenue, New York, N.Y. 10016.

CHEMICAL ENGINEER'S HANDBOOK: John H. Perry, McGraw Hill Book Co., Inc., 330 W. 42nd Street, New York, N.Y. 10036.

CHEMICAL INDUSTRY FACTS BOOK, THE: Manufacturing Chemists Association, Inc., 1825 Connecticut Avenue, Washington, D.C. 20009.

CHEMICAL PROCESS INDUSTRIES, THE: R. N. Shreve, McGraw-Hill Book Co., Inc., 330 W. 42nd Street, New York, N.Y. 10036.

COLLIERS ENCYCLOPEDIA: Collier-Macmillan Library Service Division, 60 Fifth Avenue, New York, N.Y. 10011.

COMMERCIAL ATLAS AND MARKETING GUIDE: Rand McNally & Co., Box 7600, Chicago, Ill. 60680.

COMPILATION OF AIR POLLUTANT EMISSION FACTORS: Publication No. 999-AP-42, U. S. Government Printing Office, Washington, D.C. 20402.

CONSERVATION YEARBOOK: U. S. Government Printing Office, Washington, D.C. 20402.

CONTROL TECHNIQUES FOR CARBON MONOXIDE EMISSIONS FROM STATIONARY SOURCES: Publication No. AP-65, U. S. Government Printing Office, Washington, D.C. 20402.

CONTROL TECHNIQUES FOR CARBON MONOXIDE, NITROGEN OXIDE AND HYDROCARBON EMISSIONS FROM MOBILE SOURCES: Publication No. AP-66, U. S. Government Printing Office, Washington, D.C. 20402.

CONTROL TECHNIQUES FOR HYDROCARBON AND ORGANIC SOLVENT EMISSIONS FROM STATIONARY SOURCES: Publication No. AP-68, U. S. Government Printing Office, Washington, D.C. 20402.

CONTROL TECHNIQUES FOR NITROGEN OXIDE EMISSIONS FROM STATIONARY SOURCES: Publication No. AP-67, U. S. Government Printing Office, Washington, D.C. 20402.

CONTROL TECHNIQUES FOR PARTICULATE AIR POLLUTANTS: Publication No. AP-51, U. S. Government Printing Office, Washington, D.C. 20402.

CONTROL TECHNIQUES FOR SULFUR OXIDE AIR POLLUTANTS: Publication No. AP-52, U. S. Government Printing Office, Washington, D.C. 20402.

CUMULATIVE BOOK INDEX: H. W. Wilson Co., 950 University Avenue, Bronx, N.Y. 10452.

DICTIONARY OF APPLIED CHEMISTRY: J. Thorpe, John Wiley & Sons, Inc., 605 3rd Avenue, New York, N.Y. 10016.

ENCYCLOPAEDIA BRITANNICA: Encyclopaedia Britannica, Inc., 425 N. Michigan Avenue, Chicago, Ill. 60611.

ENCYCLOPEDIA AMERICANA, THE: Americana Corporation, 575 Lexington Avenue, New York, N.Y. 10022.

ENCYCLOPEDIA OF CHEMICAL REACTIONS: C. A. Jacobson and Clifford A. Hampel, Reinhold Publishing Corp., Book Division, 430 Park Avenue, New York, N.Y. 10022.

ENCYCLOPEDIA OF CHEMISTRY, THE: Clark and Hawley, Reinhold Publishing Corp., Book Division, 430 Park Avenue, New York, N.Y. 10022.

ENCYCLOPEDIA OF THE SOCIAL SCIENCES: The Macmillan Co., 60 Fifth Avenue, New York, N.Y. 10011.

ENCYCLOPEDIC DICTIONARY OF PHYSICS: J. Thewlis, Pergamon Press, 44-01 21st Street, Long Island City, N.Y. 11101.

ENGINEERING INDEX: Engineering Index, Inc., 345 E. 47th Street, New York, N.Y. 10036.

ENGINEERING MATERIALS HANDBOOK: Charles L. Mantell, McGraw Hill Book Co., Inc., 330 W. 42d Street, New York, N.Y. 10036.

FLOW METER ENGINEERING HANDBOOK: C. F. Cusick, Honeywell, Inc., Port Washington, Pa. 19034.

HANDBOOK OF AIR POLLUTION: Publication No. 999-AP-44, U. S. Government Printing Office, Washington, D.C. 20402.

HANDBOOK OF CHEMISTRY AND PHYSICS: Chemical Rubber Publishing Co., 2310 Superior Avenue, N.E., Cleveland, Ohio 44114.

INDUSTRIAL POLLUTION CONTROL HANDBOOK: Herbert F. Lund, McGraw Hill Book Co., Inc., 330 W. 42nd Street, New York, N.Y. 10036.

INTERNATIONAL CRITICAL TABLES: McGraw Hill Book Co., Inc., 330 W. 42nd Street, New York, N.Y. 10036.

INTERNATIONAL DICTIONARY OF PHYSICS AND ELECTRONICS: Van Nostrand Co., Inc., Princeton, N.J. 08540.

INTERSOCIETY COMMITTEE METHODS FOR AMBIENT AIR SAMPLING AND ANALYSIS: American Public Health Association, 1740 Broadway, New York, N.Y. 10019.

LABORATORY METHODS: Air Pollution Control District, County of Los Angeles, 434 S. San Pedro Street, Los Angeles, Calif. 90013.

LABOR POLICY AND PRACTICE: Bureau of National Affairs, Inc., 1231 24th Street, Washington, D.C. 20037.

LIBRARY OF CONGRESS CATALOG: U. S. Library of Congress, Washington, D.C. 20000.

MANUAL FOR PROCESS ENGINEERING CALCULATIONS: McGraw Hill Book Co., Inc., 330 W. 42nd Street, New York, N.Y. 10036.

MARK'S STANDARD HANDBOOK FOR MECHANICAL ENGINEERS: Theodore Baumeister, McGraw Hill Book Co., Inc., 330 W. 42nd Street, New York, N.Y. 10036.

McGRAW HILL ENCYCLOPEDIA OF SCIENCE AND TECHNOLOGY: McGraw-Hill Book Co., Inc., 330 W. 42nd Street, New York, N.Y. 10036.

METALS HANDBOOK: American Society for Metals, Technical Book Dept., Novelty, Ohio 44072.

MOODY'S INDUSTRIAL MANUAL: Moody's Investor's Service, 99 Church Street, New York, N.Y. 10007.

OXFORD ENGLISH DICTIONARY: Oxford University Press, Inc., 417 Fifth Avenue, New York, N.Y. 10016.

PARTICLE ATLAS, THE: Walter C. McCrone, Ann Arbor Science Publishers, Inc., Box 1425, Ann Arbor, Mich. 48106.

POOR'S REGISTER OF CORPORATIONS, DIRECTORS, AND EXECUTIVES: Standard and Poor's Corporation, 345 Hudson Street, New York, N.Y. 10014.

POWER TEST CODE: American Society of Mechanical Engineers, United Engineering Center, 345 E. 47th Street, New York, N.Y. 10017.

PROFILE OF AIR POLLUTION CONTROL: Los Angeles Air Pollution Control District, 434 S. San Pedro Street, Los Angeles, Calif. 90013.

READER'S GUIDE TO PERIODICAL LITERATURE, THE: H. W. Wilson Co., 950 University Avenue, Bronx, N.Y. 10452.

RECOGNITION OF AIR POLLUTION INJURY TO VEGETATION: A PICTORIAL ATLAS: Jay S. Jacobson and A. Clyde Hill, Air Pollution Control Association, 4400th Avenue, Pittsburgh, Pa. 15213.

RESEARCH AND DEVELOPMENT ABSTRACTS: U. S. Atomic Energy Commission, Washington, D.C. 20000.

SCIENTIFIC AND TECHNICAL SOCIETIES OF THE UNITED STATES AND CANADA: National Academy of Sciences, National Research Council, 2101 Constitution Avenue, N.W., Washington, D.C. 20000.

SOURCE TESTING HANDBOOK FOR AIR POLLUTION CONTROL: A. T. Rossano, Jr. and H. B. Cooper, Environmental Science Services, 24 Danbury Road, Wilton, Conn. 06897.

STANDARD METHODS FOR THE EXAMINATION OF WATER AND WASTEWATER: American Public Health Association, 1740 Broadway, New York, N.Y. 10019.

STATISTICAL ABSTRACT OF THE U.S.: Department of Commerce, Washington, D.C. 20402.

TEMPERATURE-ITS MEASUREMENT AND CONTROL IN SCIENCE AND INDUSTRY: American Institute of Physics, 335 East 45th Street, New York, N.Y. 10017.

THOMAS REGISTER: Thomas Publishing Co., 461 Eighth Avenue, New York, N.Y. 10001.

VAN NOSTRAND'S SCIENTIFIC ENCYCLOPEDIA: D. Van Nostrand Co., Inc., 120 Alexander Street, Princeton, N.J. 08540.

WEBSTER'S INTERNATIONAL DICTIONARY: G. & C. Merriam Co., 47 Federal Street, Springfield, Mass. 01102.

Technical Journals, Periodicals, and Trade Magazines

The importance of this part of the library content must be re-emphasized. The publications listed represent the most authoritative, most recent, and most thorough presentation of new information and new applications of principles to a given specific area of applied science. It is essential that both instructors and students make frequent and systematic use of such literature to keep their technological information up to date.

Careful selectivity should be exercised in retaining, binding, or microfilming periodicals for permanent library use. Some represent important reference material which may be used for many years. For example, certain issues of the Federal Register contain regulations, criteria, standards and testing and analytical procedures for air pollutants published by the Environmental Protection Agency. However, some, especially the trade journals, should not be bound for permanent reference material because the important material which they contain will usually become a part of a handbook or textbook or be presented in a more complex and usable form within a year of so.

The following is a typical list of technical journals, periodicals, and trade magazines which would be desirable in the library. This list is given as an example which may suggest appropriate publications to those who are concerned with this type of content for a library supporting air pollution technology programs.

AIR AND WATER NEWS: McGraw Hill, Inc., 330 W. 42nd Street, New York, N.Y. 10036.
AIR CONDITIONING, HEATING AND VENTILATING: Industrial Press, 200 Madison Avenue, New York, N.Y. 10016.
AIR CURRENTS: Citizens for Clean Air, Inc., 40 W. 57th Street, New York, N.Y. 10019.
AMERICAN CITY: Butterheim Publishing Corp., Berkshire Common, Pittsfield, Mass. 01201.
AMERICAN INDUSTRIAL HYGIENE ASSOCIATION JOURNAL: American Industrial Hygiene Association, 14125 Prevost Street, Detroit, Mich. 48227.
AMERICAN PUBLIC WORKS ASSOCIATION REPORTER: American Public Works Association, 1313 E. 60th Street, Chicago, Ill. 60610.
AMERICAN SCIENTIST: The Society of the Sigma Xi, 155 Whitney Avenue, New Haven, Conn. 06510.
ANALYTICAL CHEMISTRY: American Chemical Society, 1155 16th Street, N.W., Washington, D.C. 20036.
ARCHIVES OF INDUSTRIAL HEALTH: American Medical Association, 535 N. Dearborn Street, Chicago, Ill. 60610.
ASCE SANITARY ENGINEERING DIVISION JOURNAL: American Society of Civil Engineers 345 E. 47th Street, New York, N.Y. 10017.
ASHRAE JOURNAL: HEATING, REFRIGERATION & AIR CONDITIONING: 345 E. 47th Street, New York, N.Y. 10017.
ATMOSPHERIC ENVIRONMENT: Pergamon Press, 4401 21st Street, Long Island City, N.Y.
BUSINESS WEEK: McGraw Hill Book Co., Inc., 330 W. 42nd Street, New York, N.Y. 10036.
CHEMICAL ABSTRACTS: American Chemical Society, 1155 16th Street, N.W., Washington, D.C. 20036.
CHEMICAL ENGINEERING: McGraw Hill, Inc., 330 W. 42nd Street, New York, N.Y. 10036.
CLEAN AIR NEWS: Commerce Clearing House, Inc., 4025 W. Peterson Avenue, Chicago, Ill. 60646.
COMPOST SCIENCE: Robert Rodale, Publisher, 33 Minor Street, Emmaus, Pa. 18049.
CONSUMER REPORTS: Consumers Union of U. S., Inc., 256 Washington Street, Mount Vernon, N.Y. 10550.
CURRENTS: Manufacturing Chemists Association, 1825 Connecticut Avenue, N.W., Washington, D.C. 20009.
ENVIRONMENT: Committee for Environmental Information, 438 N. Skinker Boulevard, St. Louis, Mo. 63130.
ENVIRONMENTAL SCIENCE AND TECHNOLOGY: American Chemical Society, 1155 16th Street, N.W., Washington, D.C. 20036.
FEDERAL REGISTER: National Archives, U. S. Government Printing Office, Washington, D.C. 20402.
INDUSTRIAL AND ENGINEERING CHEMISTRY: American Chemical Society, 1155 16th Street, N.W. Washington, D.C. 20036.
JOURNAL OF THE AIR POLLUTION CONTROL ASSOCIATION: Air Pollution Control Association, 4400 5th Avenue, Pittsburgh, Pa. 15253.
JOURNAL OF APPLIED METEOROLOGY: American Meteorological Society, 45 Beacon Street, Boston, Mass. 02108.
JOURNAL OF ENVIRONMENTAL HEALTH: National Association of Sanitarians, 1550 Lincoln Street, Denver, Col. 80203.
JOURNAL OF LABORATORY AND CLINICAL MEDICINE: C. V. Mosby Co., 3207 Washington Boulevard, St. Louis, Mo. 63103.
POLLUTION ABSTRACTS: Box 2369, Dept. W., La Jolla, Calif. 92037.
POLLUTION EQUIPMENT NEWS: Richard Rimbach, Sr., Publisher, 8550 Babcock Boulevard, Pittsburgh, Pa. 15237.
PUBLIC WORKS: Public Works Journal Corp., Inc., 220 S. Broad Street, Ridgewood, N.J. 07451.
SCIENCE: American Association for the Advancement of Science, 1515 Massachusetts Avenue, N.W., Washington, D.C. 20005.
SCIENCE NEWS: Science Service, Inc., 1719 N. Street, N.W., Washington, D.C. 20006.
SCIENTIFIC AMERICAN: 415 Madison Avenue, New York, N.Y. 10017.
SOLID WASTES MANAGEMENT: RRJ Publishing Corp., 150 E. 52nd Street, New York, N.Y. 10022.
WATER CONTROL NEWS: Commerce Clearing House, Inc., 4025 W. Peterson Avenue, Chicago, Ill. 60646.
WATER RESEARCH: Pergamon Press, 44-01 21st Street, Long Island City, N.Y. 11101.
WPCF JOURNAL: Water Pollution Control Federation, 3900 Wisconsin Avenue, Washington, D.C. 20016.

The Book Collection

The American Library Association states that "a 2-year institution of up to 1,000 students (full-time equivalent) cannot discharge its mission without a carefully selected collection of at least 20,000 volumes, exclusive of duplicates and textbooks. Institutions with broad curriculum offerings will tend to have larger collections; an institution with a multiplicity of programs may need a minimum collection of two or three times the basic figure of 20,000 volumes. The book holdings should be increased as the enrollment grows and the complexity and depths of course offerings expand. Consultation with many junior college librarians indicates that for most, a convenient yardstick would be the following: The bookstock should be enlarged by 5,000 volumes for every 500 students (full-time equivalent) beyond 1,000."

At the initiation of a given technology program, the head of the program and the librarian should review the current pertinent reference books available and list books to be placed in the library as regular reference material. A recommended policy is to place in the library only those reference books which are not a part of the regular textbook material for the various air pollution technology courses.

At the beginning of the program, the library should contain at least 200 or 300 reference books on various aspects of the technology specialty and its related fields. Beyond the initial 200 or 300 books there should be regular and systematic additions to the reference materials in the library supporting the technology from year to year, and eventually a weeding out of those references which have become obsolete.

Visual Aids

The procedure outlined above for the acquisition of books pertinent to the air pollution technology program is also suggested for placing the visual aids in the library. Both the librarian and the head of the program should review and evaluate visual aids materials as they become available; and those which are considered appropriate should be borrowed for special use or purchased for regular use.

In addition to the visual aids for teaching physical science principles, there are valuable films showing research, testing, and presenting factual information which should be used selectively in teaching air pollution technology.

Appendix B

SOCIETIES AND AGENCIES PERTINENT TO THE EDUCATION OF AIR POLLUTION TECHNICIANS

A list of some of the professional, scientific, and technical societies concerned with air pollution technology may be a useful source of instructional information and reference data.

The selected which follows is not a complete listing of all such organizations; and inclusion does not imply special approval of an organization, nor does omission imply disapproval of an organization. Details regarding local chapters or sections of societies have been omitted.

It is suggested that teachers and others desiring information from the organizations listed below should address their inquiry to "The Executive Secretary" of the organization. A request for information about the organization and its services, or for specific information usually can be answered promptly by them.

AIR POLLUTION CONTROL ASSOCIATION (APCA), 4400 Fifth Avenue, Pittsburgh, Pa. 15213.

History: Organized 1906 as International Association for the Prevention of Smoke; name changed to Smoke Prevention Association in 1915; incorporated in 1923; name changed to Smoke Prevention Association of America in 1940; name changed to Air Pollution and Smoke Prevention Association of America in 1950; name changed to present title in 1952.

Purpose: To improve air sanitation and foster control of atmospheric pollution affecting health and/or causing damage to property, and waste of natural resources, to encourage public acceptance of the necessity for atmospheric pollution prevention and assist governmental units toward a solution of this problem; to encourage the development and adoption of apparatus, equipment, and operating procedures that will economically prevent pollution of the atmosphere; to promote research in the solution of problems embracing all sources of atmospheric pollution; to prepare and distribute literature and publications pertaining to the problems involved in providing cleaner air.

Membership: Industrialists, researchers, equipment manufacturers, governmental control personnel, educators, meteorologists, and others seeking economical answers to the problems of air pollution.

Publications: *Journal of the Air Pollution Control Association; Directory of Governmental Air Pollution Agencies*

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, 1515 Massachusetts Avenue, N.W., Washington, D.C. 20005.

History: Founded 1848.

Membership: Membership includes individuals and scientific societies, professional organizations and state and city academies (many of which sp[illegible]ior academies of science).

Publications: *Science Symposium Volumes; Science Education News; AAAS Bulletin; Understanding; Science Books.*

AMERICAN CHEMICAL SOCIETY (ACS), 1155 Sixteenth Street, N.W., Washington, D.C. 20036.

History: Organized April 20, 1876, incorporated 1877; reorganized 1891-92 to secure national participation; incorporated under Federal Charter, 1938.

Purpose: To encourage in the broadest and most liberal manner the advancement of chemistry in all its branches; to promote research in chemical science and industry; to improve the qualifications and usefulness of chemists through high standards of professional ethics, education, and attainments; to increase and diffuse chemical knowledge; and by its meetings, professional contanets, reports, papers, discussions, and publications, to promote scientific interests and inquiry, thereby fostering public welfare and education, aiding the development of the country's industries, and adding to the material prosperity and happiness of its people.

Membership: Scientific, educational, and professional society of chemists and chemical engineers.

Publications: *Analytical Chemistry, Biochemistry; Chemical Abstracts; Chemical and Engineering News; Chemical Reviews; Chemistry; Environmental Science and Technology, Industrial and Engineering Chemistry, Inorganic Chemistry; Journal of Agricultural and Food Chemistry; Journal of the American Chemical Society; Journal of Chemical and Engineering Data; Journal of Chemical Documentation, Journal of Chemical Education; Journal of Medicinal Chemistry, Journal of Organic Chemistry; Journal of Physical Chemistry, Rubber Chemistry and Technology.*

AMERICAN INDUSTRIAL HYGIENE ASSOCIATION (AIHA) 14125 Prevost Avenue, Detroit, Michigan 48227.

History: Founded 1939.

Purpose: To promote the study and control of environmental factors affecting the health and well being of industrial workers.

Membership: Professional society of industrial hygienists.

Publications: *The American Industrial Hygiene Association Journal, Hygienic Guides.*

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS (AIChE), 345 East 47 Street, New York, N.Y. 10017.

History: Founded 1908.

Purpose: Conducts research projects; establishes standards for chemical engineering curricula.

Membership: Professional society of chemical engineers.

Publications: *Chemical Engineering Progress; AIChE Journal, International Chemical Engineering, Symposium Series.*

AMERICAN METEROROLOGICAL SOCIETY, 45 Beacon Street, Boston, Mass. 02108.

History: Founded 1919.

Purpose: To develop and disseminate knowledge of meteorology in all its phases and applications and to advance its professional ideals. Activities include visiting scientist and visiting foreign scientist program, a guidance service to provide weather kits of informative materials to students and teachers, career information, certification of consulting meteorologists, and a seal of approval program to recognize competence in radio and television weathercasting. Provides abstracting and translation services; maintains cumulative list of translations by language, subject, and author, with quarterly supplements.

Membership: Professional, nonprofessional, and student meteorologists and amateur weathermen.

Publications: *Bulletin of the AMS; Meteorological and Geoastrophysical Abstracts; Journal of the Atmospheric Sciences; Weatherwise; Journal of Applied Meteorology.*

AMERICAN SOCIETY FOR TESTING MATERIALS (ASTM), 1916 Race Street, Philadelphia, Pa. 19103.

History: Organized June 16, 1898, as the American Section of the International Association for Testing Materials; incorporated under present title March, 1902.

Purpose: The promotion of knowledge of the materials of engineering and the standardization of specifications and methods of testing.

Membership: Engineers, scientists and skilled technicians holding membership as individuals or as representatives of business firms, government agencies; educational institutions, laboratories.

Publications: *Materials Research and Standards Journal; Proceedings; Yearbook; Index to Standards; Book of Standards.*

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME), 345 East 47th Street, New York, N.Y. 10017.

History: Founded 1880.

Purpose: Conducts research; develops boiler and pressure vessel, and power test codes; serves as sponsor for the American Standards Association in developing safety codes and standards for equipment.

Membership: Professional society of mechanical engineers. Membership also includes student members in student sections.

Publications: *Mechanical Engineering; Transactions* (Journals of Power, Industry, Heat Transfer, Basic Engineering, Applied Mechanics); *Applied Mechanics Reviews; Mechanical Catalog.*

INCINERATOR INSTITUTE OF AMERICA, 60 East 42nd Street, Suite 1914, New York, N.Y. 10017.

History: Founded 1951.

Purpose: Publishes standards which define incinerator terminology, analyze waste, classify incinerators, and state specifications of incinerators by classes. Tables show the broad classification of wastes to be incinerated and the maximum burning rate of various types of wastes.

Membership: Manufacturers of incinerators for municipal, industrial, commercial, and domestic use; associate members are others related to the incineratory industry.

Publications: *IIA Incinerator Standards* (May 1966).

WATER POLLUTION CONTROL FEDERATION (WPCF), 3900 Wisconsin Avenue, Washington, D.C. 20016.

History: Founded 1928; formerly: (1949) Federation of Sewage Works Associations; (1959) Federation of Sewage and Industrial Wastes Associations.

Purpose: To advance the fundamental and practical knowledge concerning the nature, collection, treatment, and disposal of domestic and industrial wastewaters, and the design, construction, operation and management of facilities for these purposes.

Membership: Members include municipal engineers, consulting engineers, public health engineers, water pollution control works superintendents, chemists, operators, educational and research personnel, industrial wastewater engineers, municipal officials, and equipment manufacturers interested in water pollution control.

Publications: *Journal of WPCF, Highlights; Directory.*

Appendix C

SAMPLE INSTRUCTIONAL MATERIALS

The items included in this section are intended to serve as guides in the development of instructional material. The formal classwork is usually organized around textual material to facilitate the coordination of outside study. The laboratory work, by contrast, is almost entirely custom designed. This is necessary for at least two very practical reasons:

1. Little commercially published material exists for this type of instruction.
2. Laboratory work must be organized to make maximum use of available materials and facilities.

It should be emphasized that material of this nature requires careful preparation.

TYPICAL MATERIAL FOR A UNIT OF INSTRUCTION

One of the primary advantages of the full-time day program is in the coordination of classroom discussions and demonstrations of theory and practice with laboratory activities. In order to illustrate this coordination, a representative unit of instruction was selected from the course entitled Air Pollution Instrumentation. It includes:

Instructional Guide
Specific Reading Assignments
Laboratory Unit Related to Instruction
Suggested Standards for Laboratory Reports

INSTRUCTIONAL GUIDE

Air Pollution Instrumentation

Topic: Division IV-4 calibration of flow meters
Lecture Time: Two 60-minute periods
Laboratory Time: Two 3-hour periods
Outside Study: Four hours (minimum)

Lecture 1: Basic calibration considerations

Reference: Baumeister. *Mark's Standard Handbook for Mechanical Engineers*, pp. *3*-48 to *3*-76 and *16*-18 to *16*-22.

1. Characteristics of fluid
2. Desired accuracy of flow measurement
3. Calibration standards
4. Time available for calibration
5. Location of flow measuring device (illustrations)
6. Temperature and pressure readings
7. Summarize

ASSIGNMENT FOR NEXT LECTURE PERIOD.

Reading Assignment: Perry. *Chemical Engineer's Handbook*, Section 5 and Cusick. *Flow Meter Engineering Handbook*, pp. 1-14.

Problem Assignment: (1) Assign a problem illustrating the use of weight-time measurements for determining the flow rate of a liquid through a pipe. (2) Assign a problem illustrating the equal-area method of determining the average velocity of a fluid in a duct with a pitot tube.

Lecture 2: Calculation of discharge coefficients and correction factors

1. Derivation of a universal formula for fluid measurement
2. Ideal flow equations for standard rate meters
3. Experimental methods of determining discharge coefficients
4. Graphic illustrations
5. Summarize

ASSIGNMENT FOR NEXT LECTURE PERIOD

Reading Assignment: Baumeister. *Mark's Standard Handbook for Mechanical Engineers*, pp. 4-80 to 4-89.

Problem Assignment: Assign problems illustrating the use of the psychrometric charts.

LABORATORY UNIT

Purpose: Compare accuracy and calibration techniques of several common rate meters.

Equipment: Fan test apparatus equipped with a pitot tube, traverse device, venturi meter, orifice plate, and elbow section.

Description: Adjusting the flow rate through the fan test apparatus, make a pitot tube traverse and record the velocity head for each flow measuring device at several different flow rates. Measure the wet- and dry-bulb temperature of the gases passing through the meters. The velocity of air at the pitot tube traverse points may be calculated with the equations:

$$V = 2.90\, F_p \sqrt{\left[\frac{29.92}{P_s}\right]\left[\frac{1.00}{D}\right] HT}$$

V-Velocity of gas at point, feet per second
F_p-Calibration factor for pitot tube
P_s-Static pressure of the gas, inches of mercury
D-Specific gravity of the gases, referred to air
H-Velocity head, inches of water
T-Gas temperature, degrees Rankine

The average velocity of the gases for n number of readings may be caluclated:

$$V\ \text{avg.} = \frac{\Sigma\, V_i}{n}$$

If all the variables (with the exception of H) are constant for a traverse, the average velocity may be calculated with the equation:

$$V\ \text{avg.} = 2.90\, F_p\, H_{ra} \sqrt{\left[\frac{29.92}{P_s}\right]\left[\frac{1.00}{D}\right] T}$$

Where H_{ra} (the average of the square root of the velocity head) is defined as:

$$H_{ra} = \frac{\Sigma \sqrt{H_i}}{n}$$

The flow rate may be calculated using the average velocity and the cross sectional area at the traverse points:

$$Q = (V\ \text{avg.})\ (A)$$

Where Q-Flow rate, cfs
A-Cross sectional area, ft.^{2}

The discharge coefficient for the other flow measuring devices may be calculated using the equation:

$$C_d = \frac{Q}{A_2 \sqrt{\frac{2\,(P_1 - P_2)}{p\,[1-(d_2/d_1)^4]}}}$$

Where A_2-area of orifice opening

P_1, P_2-upstream and downstream pressures, respectively

ρ-gas density

d_2/d_1-ratio of orifice diameter to pipe diameter

Q-actual flow rate through meters as determined by the pitot traverse

Compare the discharge coefficients with those furnished by the manufacturer.

Repeat the previous unit for liquid flow through a set of liquid rate meters, e.g., a venturi meter, an orifice, a rotameter, and a weir box. Use the weight rate method to determine the flow rate of water through these meters.

The equation for the discharge coefficient for the weir box with a triangular notch is:

$$C_d = \frac{Q}{\frac{8}{15} h^2 \sqrt{2gh} \tan a/2}$$

h = weir head
a = angle of the notch

LABORATORY REPORT

Much of the effectiveness of formal training rests upon the standards required in reporting. Employers stress the importance of communications, especially for the liaison type jobs so often assigned to the technician. Perhaps the most thorough approach to this in the instructional program is found in the formal and informal reporting (whether oral or written) of laboratory projects, and also in design problems, research studies, and field study of industrial installation.

The form and style of the formal report should be established early in the program in order to attain a degree of uniformity. The guide used should direct attention to the importance of detail as well as logical conclusions in the reporting process.

The making of the report itself constitutes an important part of the instruction. Unless this is done carefully and as objectively as possible the student may be misled and actually misinformed.